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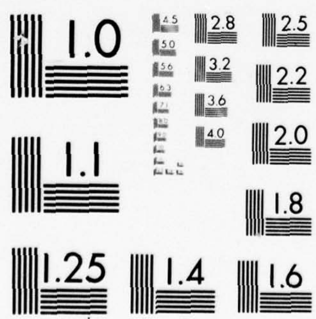

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PROTECTIVE COATINGS FOR STEEL PILING: ADDITIONAL DATA ON HARBOR EXPOSURE OF TEN-FOOT SIMULATED PILING

By

Robert L. Alumbaugh, PhD and A. F. Curry

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This final report, supplement to CEL Technical Report TR-711, presents additional results of the investigation of protective coating systems of various generic types that were applied to 10-foot steel panels. These simulated steel pilings were suspended from a corrosion dock in the mouth of Port Hueneme Harbor so that the bottom portion was in continuous immersion, the middle portion in the tidal zone, and the top portion in the atmosphere. Results are given for coating systems that were performing satisfactorily at the time TR-711

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This final report, supplement to CEL Technical Report TR-711, presents additional results of the investigation of protective coating systems of various generic types that were applied to 10-foot steel panels. These simulated steel pilings were suspended from a corrosion dock in the mouth of Port Hueneme Harbor so that the bottom portion was in continuous immersion, the middle portion in the tidal zone, and the top portion in the atmosphere. Results are given for coating systems that were performing satisfactorily at the time TR-711 was issued. Exposure times for the 85 coating systems suspended from the corrosion dock ranged from 9 to 21-1/2 years.

CONTENTS

INTRODUCTION

This is the final report covering results of the investigation of protective coatings for steel piling applied and cured before being subjected to a marine environment. The candidate coating systems were applied to simulated steel pilings, which were suspended from the corrosion dock in the mouth of the harbor at Port Hueneme, California. Exposure times varied from 9 to 21-1/2 years. This report is to be used in conjunction with TR-711 [1], which it supplements.

TEST PROCEDURE

Laboratory Tests

Most of the coating systems included in this investigation were analyzed to determine compositional and physical properties. These included percentage by weight of nonvolatile solids, pigment, nonvolatile vehicle, ash, weight per gallon, specific gravity, and consistency or viscosity in Krebs units. Methods used and results of the analysis are presented in Reference 1.

Field Tests

The simulated steel piling used as the substrate in this investigation were 1/4-inch by 4-inches by 10-feet in size. Coated panels were suspended from the corrosion dock in the mouth of Port Hueneme Harbor so that the top portion of the 10-foot panels was exposed to the atmosphere (zone a). The middle portion was exposed to tidal changes (zone b), and the bottom portion was completely submerged (zone c). Descriptions of the coating systems still exposed after publication of Reference 1 are given in Appendix A. Names and sources of these coating materials are given in Reference 1 as is more detailed information on panel preparation, coating application, and exposure conditions.

EVALUATION PROCEDURE

The coating systems were evaluated and rated periodically to determine their performance. Coating system performance characteristics were rated according to appropriate ASTM photographic reference standards when these were available. These ratings were assigned to each of the exposure zones - a, b, and c. ASTM standards are available for chalking, checking, cracking, blistering, and rusting. These methods use a

rating of 10 to indicate a perfect coating system without defects, while 0 indicates a coating that has failed completely in the rated area. Where applicable, ratings were also assigned to other film failure characteristics or environmental conditions such as flaking, fouling attachment, fouling damage, pitting (and galvanic corrosion), and undercutting. More detailed information on rating criteria and methods is presented in Reference 1.

Since the ultimate objective of this project was to determine how well a given coating system protects the steel substrate from rusting, a protection rating was assigned to each of the three zones of each coated panel. This protection rating was often the same as the ratings assigned to rusting, since this latter factor was more heavily weighted than any of the others in determining the ability of the coatings to protect the steel. In some cases this protection rating differed from that assigned to rusting, indicating that one or more of the other coating deterioration factors had progressed to the point where the protection rating of the coating system was lowered.

When a coating system had deteriorated to the extent that the protection rating in one zone was 5 or less, or that two of these zones were rated 7 or less, the system was considered to have failed and was removed from the test. In a few exceptional cases, a coating in one zone was assigned a protection rating of 5, and the same coating in the other two zones was in excellent condition. In these cases, the panels were exposed longer. Ratings are tabulated in Appendix B, presented in graphic form in Figure 1, and discussed in detail later in the report.

SCOPE OF THE STUDY

Due to the large number of panels exposed, the panels were grouped initially in various series for convenient presentation. Inclusion of panels within a given series was determined by the type of panel, coating system, and chronological order in which the panels were exposed. In Series 1 the coatings were applied to 2-1/2-inch by 10-foot angle-iron panels; the remaining series were applied to 1/4-inch by 4-inch by 10-foot-long steel panels. Systems that were reported as having failed in the earlier reports are not included in this current supplement. Thus, only those systems are listed and described that were still performing satisfactorily when Reference 1 was published. The various series are listed below:

Series 1 – System numbers between 1 and 15 that remain on exposure. This was the first group of panels that was exposed and consisted of various coating systems applied to the panels exposed on the corrosion dock. Only 3 of the original 15 systems are reported.

Series 2 – System numbers between 16 and 55 that remain on exposure. This series consisted of 4-inch by 10-foot panels in which 10 coating systems had each been applied over four different surfaces. The four different surface treatments were:

a. Sandblasted steel

b. Formula 117 pretreatment primer over sandblasted steel

c. Flame-sprayed zinc wire over sandblasted steel

d. Flame-sprayed aluminum wire over sandblasted steel

Only 10 of the original 40 panels were performing satisfactorily and are included in this report.

Series 4* – System numbers between 66 and 86 that remain on exposure. These were the same systems that were applied to the coated steel piling reported in Reference 2. These coating systems were applied to the 4-inch by 10-foot panels at the same time they were applied to the steel piling. Only three of these systems remained exposed and are reported here.

Series 5 – System numbers between 87 and 127 that remain on exposure. This series consisted of various generic types of coating systems applied to sandblasted steel panels initially exposed over a period of years on the corrosion dock. Twenty-four of 41 systems are reported here.

Series 6 – Systems 128 through 144. This series consisted of various self-cured and post-cured zinc inorganic silicate coatings overcoated with a Navy vinyl-alkyd system** and with a manufacturer-recommended coating system.

Series 7 – Systems 145, 145a through 148, 148a. These systems consisted of catalyzed polyester resin coatings, most of which were filled with either fiberglass or flakeglass.

Series 8 – Systems 149 through 169. This series consisted of several zinc-filled epoxies, each of which was overcoated with a manufacturer-recommended coating system, an aluminum vinyl system, a vinyl mastic system, and saran.

Many of the above coating systems were also exposed on 10-foot angle iron panels driven into the surf at Port Hueneme Harbor. However, these systems sustained very heavy damage during a severe storm immediately following publication of TR-711. As a result, Reference 1 contains the final available data on these systems.

RESULTS AND DISCUSSION

Performance of the various systems exposed on the corrosion dock is described in this report. Ratings indicating the performance of the coating systems are listed in Appendix B and discussed in the following section according to the series in which they were exposed; their per-

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*Series 3 consisted of metal-pigmented organic and inorganic coatings, all of which were reported as failed in Reference 3.

**Hereafter, generally referred to as a "vinyl system" for brevity.

formance is also presented graphically in Figure 1. For ease of comparison, bar graphs are used to depict the average protection ratings for the systems in which the systems are grouped according to their generic type. Bar graphs for a few of the systems have been repeated when it was desirable to present them under more than one generic type or heading. Thus, bar graphs are given for Systems 36, 37, and 38 under both "Phenolics" and "Coatings Applied to Different Surface Treatments." While ratings tabulated in Appendix B are given only for the period following publication of TR-711, the bar graphs in Figure 1 illustrate performance for the total exposure period.

In Figure 1, the degree of system deteriorating or failure is denoted by a series of parallel lines within the bar. If the system was providing complete protection, the bar is only an outline. Within a given bar, and thus in a given system, the first line from the baseline of the graph indicates the approximate time of initial system deterioration (rusting). As the system deteriorates, the lines within the bar become progressively closer together; a completely darkened area at the end of the bar represents failure and removal of the system from exposure. It should be noted that, if a system provided relatively good protection to the panel, the spacing between the end of the bar graph and the line immediately next to it is not significant. Zones in which failure occurred are listed at the top of the bar graph for the corrosion dock panels.

In the discussion of the performance of the systems that follows, protection ratings for the three exposure zones are often given without further identification; for example, a rating of 10,9,9 indicates the protection ratings assigned for zones a (atmospheric), b (tidal), and c (submerged), respectively.

SERIES 1 - ANGLE IRON PANELS SUSPENDED FROM CORROSION DOCK

The three systems of this series that remain exposed are System 10 (saran, 6 mils, applied by brush); System 13 (flame-sprayed aluminum powder, 4.5 mils); and System 15 (flame-sprayed aluminum wire, 5.0 mils). These three systems provided complete protection to the steel panels for 6 to 7 years and varying protection with continued exposure.

Saran

The saran-coated panel (System 10) exhibited very light rusting and pitting in zone c after 7 years. Continued deteriorating of this system was very gradual. It was not until between the 18-1/2 and 19-1/2 year exposure period that the protection rating dropped below the 10,9,8 that had been assigned after 15-1/2 years of exposure. Pitting gradually became more severe, particularly in zone c while blistering remained light in all three zones. After 21-1/2 years of exposure, this saran system was performing relatively well in zones a and b, had failed in zone c and was rated as 10,8,7.

Flame-Sprayed Aluminum

System 13, the flame-sprayed aluminum powder, performed extremely well during the 21-year exposure period. Very gradual dissolution of the flame-sprayed aluminum from zones b and c permitted light rusting and light pitting in zone c. After 21 years of exposure, the protection rating assigned was 10,9,9.

The flame-sprayed aluminum wire, System 15, had failed after 15 years of exposure (rated 9,8,5) because of the protection rating of 5 in zone c. However, it had remained exposed because of moderately good performance in zones a and b (see Reference 1). Because much of the aluminum metal had been removed in zones b and c, rusting and galvanic corrosion were quite heavy, particularly in zone c. After 16 years of exposure, this system was rated at 9,5,2 in the three zones and was removed from the test.

SERIES 2 - SYSTEMS APPLIED OVER FOUR DIFFERENT SURFACE TREATMENTS

This series originally consisted of 10 different coatings of coating systems applied over four different surface treatments. The objective was to find the surface treatment most effective in a combination coating system. Of the original 40 panels exposed, only 10 systems remained exposed following publication of TR-711 [1]. Six of these ten systems have failed in the ensuing exposure period. Of the coatings applied directly to bare steel or over Formula 117, three are still providing moderate protection after 20 years of exposure; i.e., System 17 (saran over Formula 117), System 36 (Phenolic mastic over bare steel), and System 37 (Phenolic mastic over Formula 117). The fourth system still providing moderately good protection to the steel substrate after 20 years is System 22 (Formula 119 over flame-sprayed zinc).

Saran

Of the three sarans, System 16 (saran over bare steel) and System 17 (saran over Formula 117) degraded at about the same rate. System 16 exhibited more galvanic corrosion and pitting in zone c and undercutting along edges than did System 17. This is attributed to the wash primer (Formula 117) of System 17, acting as an inhibitive primer. After 20 years of exposure, System 16 was rated 9,6,5 and had failed while System 17 was still providing moderate protection in two out of three zones and was rated 9,8,7. Although System 16 has been used as a standard in this study, it is no longer available since the specification covering the material has been canceled. System 18 (saran over flame-sprayed zinc) provided better protection for a longer period but had also failed by the 20-year exposure period. It was assigned a protection rating of 10,8,5 at that time. It was noted that although black rust products were observed in zones b and c, no galvanic corrosion or pitting was

evident. This was attributed to sacrificial action of the flame-sprayed zinc coating. Also, this system was providing complete protection to the steel in the atmospheric zone.

Vinyls

System 22 (Formula 119 over flame-sprayed zinc) and System 34 (vinyl finish over flame-sprayed zinc) were the only vinyls remaining on exposure when the series was last reported [1]. At that time, System 34 was near failure and had failed after 15 years of exposure with a protection rating of 9,6,5. The coating was badly deteriorated in zones b and c, permitting general rusting along with pitting and galvanic corrosion. System 22, however, was still providing relatively good protection and was rated 9,9,8 after 20 years of exposure. Although the vinyl topcoat showed moderate to dense blistering, good protection was still being provided by the flame-sprayed zinc.

Phenolic Mastic

At the conclusion of the 20-year exposure period, all three phenolic mastic systems were still in the program; i.e., System 36 (Phenolic mastic over bare steel), System 37 (Phenolic mastic over Formula 117) and System 38 (Phenolic mastic with mica filler over bare steel). However, at the last rating period, System 38 was rated 5,9,8 and had failed due to medium to heavy undercutting by rust in the atmospheric zone (zone a). As noted previously [1], undercutting is usually not characteristic of this phenolic system. Systems 36 and 37 were providing about the same degree of protection to the steel substrate after 20 years; System 36 was rated as 8,9,8, while System 37 was rated 9,9,8. Thus, the wash primer, Formula 117, did not add appreciably to the performance of this system.

Epoxy

System 42 (epoxy over flame-sprayed zinc) was the only epoxy remaining at the beginning of this reporting period. Blistering of the epoxy system from the flame-sprayed zinc continued to be a problem and was rated few to medium dense in the three zones. As these blisters ruptured, the zinc coating corroded, eventually permitting light rusting and pitting in zone c. After 20 years, this system was assigned a protection rating of 7,9,7, denoting failure, and was removed from the test.

Furan

System 50 (furan over flame-sprayed zinc) was the only furan system remaining at the beginning of this exposure period. However, at that time, the system was nearing failure because of medium to dense blistering and corrosion of the zinc coating and steel substrate. This system was rated 7,7,8 after 16 years of exposure, was considered to have failed and was removed from the test.

Summary of Series 2 Systems

Only four of the ten systems of Series 2 still exposed following publication of Reference 1 were performing satisfactorily after 20 years of exposure. These were Systems 17, System 22, System 36 and System 37. All four of these systems were superior to the saran standard (System 16) in performance. Systems 22, 36 and 37 performed similarly while System 17 was only slightly less effective.

Systems 18, 38, and 42 were all equal in performance to the test standard (System 16), while both Systems 34 and 50 provided less effective protection than the standard. Of the four surface treatments investigated in this series, the flame-sprayed zinc appears to be most effective. Five of the ten topcoat systems investigated in this series, when applied over the flame-sprayed zinc coating, extended the life expectancy of the zinc about four times.

SERIES 4 - COATING SYSTEMS TESTED IN FULL-SCALE PILING TEST [4,5]

The three coating systems in this series that remained exposed after publication of TR-711 are System 71 (vinyl mastic), System 72 (phenolic mastic) and System 84 (flame-sprayed aluminum).

Vinyl Mastic

System 71 has remained exposed longer than any of the other vinyls. However, after 18-1/2 years of exposure, this system exhibited varying degrees of blistering, undercutting by rust, galvanic corrosion, and pitting, particularly in zones b and c. The system was rated 9,6,7, was considered to have failed, and was removed from the test.

Phenolic Mastic

System 72 was composed of a mica-filled phenolic mastic primer and a phenolic mastic finish coat and was essentially identical to System 38. This system performed very well over the years, generally exhibiting only light blistering and rusting. After 18-1/2 years of exposure, performance of the system was relatively good, and it was rated 8,9,8.

Flame-Sprayed Aluminum Wire

The protection provided to the steel substrate by System 84 has been very good. While aluminum has been consumed by seawater, particularly in zone b, the system is rated 9,8,9 after 18-1/2 years of exposure. Although not quite as effective as System 13, a flame-sprayed aluminum powder, it still is a good performer.

Summary of Series 4 Systems

It is interesting to note that Systems 71 and 72 were two of the three best systems tested in the longer-term field tests of coating systems [4,5] in which eight coating systems applied to steel sheet and "H" piles were exposed at Port Hueneme and Guam for periods ranging from 6 to 48 months. System 84 was not included in these longer-term tests. The data suggest that results obtained from simulated piling on the corrosion dock correlate relatively well with full-scale field tests in determining coating systems having superior performance.

SERIES 5 - COATING SYSTEMS OF VARIOUS GENERIC TYPES

This series originally consisted of 41 coating systems of various generic types that were exposed at different times over a 6-year period. Twenty-four of these remained exposed at the time Reference 1 was published. These included coal tar-resin blends, epoxies, miscellaneous (the remaining system being a chlorosulfonated polyethylene), phenolics, urethanes, and vinyls. Data on the performance of these systems are presented and discussed below according to generic type.

Coal Tar-Resin Blends

This group consists of five amine-cured coal tar-epoxies - Systems 87, 103 (aluminum-pigmented finish coat), 108, 117, and 118 - all of which are providing moderately good protection to the steel substrates after exposure periods of 13-1/2 to 17 years. System 114, a coal tar-urethane, had failed after 14-1/2 years of exposure.

The coal tar-epoxies appear to be one of the better generic types of coating systems for protecting steel piling in seawater. Systems 103, 117, and 118 were providing very good to excellent protection at the conclusion of the test. System 103 was providing nearly perfect protection after 16 years (rated 10,10,10) while Systems 117 and 118 were only slightly less effective, receiving protection ratings of 9,9,9 (14-1/2 years), and 9,9,10 (13-1/2 years), respectively. Systems 87 and 108 were closer to failure, being rated as 7,9,8 (17 years) and 7,9,9 (15-1/2 years), respectively. The reason for more rapid degradation of Systems 87 and 108 can be attributed to the fact that they were only one-half to three-fourths the thickness of the other three systems. Had they been applied at 16 to 18 mil thicknesses, they may have performed as well as the other systems in this group.

All coal tar-epoxies appear to degrade in a similar manner. That is, blistering and undercutting by rust occurs adjacent to a sharp edge or an area where the coating has been mechanically damaged. Also, it is not uncommon to find adhesion problems with these materials where the finish coat flakes from the undercoat. This latter problem is attributed to the undercoat curing for too long a period prior to application of the finish coat.

System 114, the coal tar-urethane, did not become quite as hard (and, hence, as brittle) as the coal tar-epoxies. As a result this coating was subject to light fouling damage in zones b and c as well as light to moderate blistering in all three zones. After 14-1/2 years, this system was rated 5,7,9, had failed, and was removed from test.

Epoxies

This group consists of two polyamide-cured epoxies (Systems 109 and 110) and six amine-cured epoxies (Systems 97, 100, 101, 116, 123 and 124). Systems 109 and 110 were identical except that System 110 included a tetrafluorethylene emulsion topcoat which increased the system thickness by 1 mil. The topcoat was added to find if such a surface would reduce the amount of fouling attachment. While fouling attachment was reduced initially on System 110, it was normal by the beginning of this last exposure period.

Both Systems 109 and 110 performed similarly for about 13 years, showing light to moderate blistering, light rusting (particularly along edges), and light undercutting by rust. However, the coating in the atmospheric zone of System 109 degraded rapidly thereafter; after an exposure of 15-1/2 years, System 109 had failed, was rated 5,9,9, and was removed from the test. System 110 was rated 8,9,9 at the conclusion of the test. The somewhat better protection provided by System 110 is attributed to its slightly greater thickness.

Two of the six remaining amine-cured epoxies - Systems 97 and 124 - failed during this final exposure period. Both systems exhibited medium to dense blistering in all three zones and progressively heavier undercutting by rust in the atmospheric zone with continued exposure. A yellow fluid was noted under blisters on System 124 which suggests that the zinc chromate pigmented primer tended to solubilize slightly, forming the blisters. System 124 also exhibited galvanic corrosion in zone c. System 97 had failed after 16 years of exposure and was rated 5,8,8; failure of System 124 occurred after 12-1/2 years, when it was rated 5,8,9.

System 100, a zinc-filled, amine-cured epoxy, was nearing failure after 16 years of exposure, at which time it was rated 9,8,7. This system showed pinpoint rusting in all zones. Much of the zinc in zone c had been consumed, permitting heavy rusting in this area of total immersion. The blisters of agglomerated zinc pigment particles noted earlier [1] were corroding and permitting rusting of the underlying steel substrate.

Systems 101 and 116 were providing about the same degree of protection to the simulated steel piling although System 101 had been exposed for 16 years, while System 116 had been exposed only 14-1/2 years. At the conclusion of this exposure period both were rated 9,9,8. However, their modes of deterioration were somewhat different. System 101 showed light to heavy checking over the panel surface and moderate fouling damage where the topcoat had been removed from the primer by barnacles. Both systems exhibited light blistering, light pinpoint rusting, and heavier coating deterioration and rusting along the panel edges.

The best protection in the epoxy group was shown by System 123, an epoxy phenolic material. The only deterioration observed on this system for the first 10-1/2 years of exposure was light to moderate blistering. Between 10-1/2 and 11-1/2 years of exposure, light pinpoint rusting emerged. However, after 12-1/2 years of exposure on the corrosion dock, this system was still providing very good protection to the steel substrate and was rated 10,9,9.

Miscellaneous (Synthetic Rubber)

Only one panel remained exposed in this group following publication of Reference 1: System 99, a chlorosulfonated polyethylene coating. This system was near failure at the beginning of this exposure period (11 years) and did not change appreciably for the entire 6-year period. The protection rating assigned for the entire period (and at the conclusion of 16 years of exposure) was 8,6,8. The major problem appeared to be loss of adhesion of the topcoat which was attributed to a tendency of the primer to solubilize. This factor also may have been responsible for the system's not failing since the solubilized primer did tend to inhibit rusting underneath the topcoat. The tendency to solubilize was also probably responsible for the moderate to dense blistering that occurred throughout the exposure period.

Phenolic

Only one phenolic system was exposed in this series, System 120. The coating materials used in this system were lower solids variations of the phenolic mastic materials exposed as part of Series 2 and 4.

System 120 exhibited light to moderate blistering and a gradual increase in rusting during this exposure period. Galvanic corrosion became more severe, particularly in zone c. After 13-1/2 years of exposure, this system was rated 5,9,6, had failed, and was removed from test.

Urethane

All four of the urethane systems described in TR-711 were still exposed at the conclusion of this investigation. This included an aluminum pigmented urethane (System 102) and three conventionally pigmented urethanes (Systems 112, 122, and 127).

These four urethane systems were providing relatively similar protection to the simulated steel piling even though exposure times varied from 11-1/2 to 16 years. The best performance was shown by System 102, the aluminum pigmented urethane. Although the aluminum pigmented topcoat exhibited light to moderate blistering from the primer, particularly in zones b and c which removed much of the topcoat in these two zones as the blisters ruptured, the primer was still providing some protection against rusting. After 16 years of exposure this system was rated 10,9,7.

The topcoat was also removed from Systems 112 and 127, at least in part by barnacles on System 112. This latter system also exhibited light galvanic corrosion and light pitting in zone b. System 127 showed light to dense blistering; where blisters had ruptured, the zinc chromate primer was providing some protection. System 112 was rated 9,8,8 after 14-1/2 years while System 127 performed similarly and was rated 9,9,7 after 11-1/2 years of exposure.

System 112, like System 127, included a zinc chromate primer. This may have been somewhat responsible for the light to dense blistering that occurred with this system. Most of the blisters at this point in the exposure were filled with rust (Type 2) and were rigid. In addition, the panel was covered with light pinpoint rusting and exhibited heavy rusting along the edges. This system showed the poorest performance of any of the urethanes. After 13-1/2 years of exposure, System 122 was nearing failure and was rated 7,8,8.

Vinyls

This group consisted of four vinyls: System 95 (an aluminum-pigmented vinyl-thiokol primer topcoated with a conventional vinyl finish coat), System 106 (an aluminum-pigmented vinyl finish over conventional vinyl primers), System 115 (a conventional vinyl system), and System 126 (the Navy vinyl system). These vinyl systems deteriorated at a similar rate but were all still exposed at the conclusion of the investigation.

The relatively good performance of System 95 in its early exposure years was attributed to the aluminum-pigmented vinyl-thiokol primer [1]. While this system was rated 9,8,7 at the conclusion of the last exposure period (11-1/2 years of exposure), it has deteriorated very slowly with continued exposure and was still rated 8,8,7 after 16-1/2 years of exposure. This relatively slow rate of system deterioration was also attributed to the system's primer since the total system thickness was quite low (5.5 mils).

System 106 was the second vinyl containing aluminum pigment. Continued deterioration of this system also has been relatively slow since the last exposure period. This deterioration consisted of light to dense blistering and light rusting over the entire panel, and galvanic corrosion and pitting in zone c. After 16 years of exposure, this system was rated 8,8,9.

System 115 showed slightly better performance than the other vinyls in this series. Deterioration consisted of light pinpoint rusting, and light checking but very little blistering. After 14-1/2 years, this vinyl system was rated 9,8,9.

The Navy vinyl, System 126, showed slight loss of adhesion, pitting, and galvanic corrosion in zone c, and light blistering over the entire panel. After 12-1/2 years, this standard Navy vinyl system was rated 9,8,8. As mentioned previously, the four vinyl systems have performed and protected the steel substrate in a similar manner.

SERIES 6 – TOPCOATED ZINC INORGANIC SILICATE COATINGS

This series was composed of several self-cured and post-cured zinc inorganic silicate coatings, each of which was topcoated with the manufacturer's recommended coating system and the standard Navy vinyl system. Because the zinc inorganic silicates are consumed relatively fast in seawater [3], they must be topcoated to extend their effective service life. Topcoating of these silicate primers can be troublesome; special precautions are required, such as scrubbing and washing the surface of the post-cured coatings with water prior to overcoating, to develop reasonably good topcoat adhesion. Also these zinc coatings must be thoroughly stirred during spray application to prevent the heavy zinc pigment from settling. Even when such precautions are exercised, the adhesion of organic coatings to the zinc inorganic silicate primers is often not comparable to that obtained for the same organic system over sandblasted steel. As a result, this series was exposed to find which of the zinc primer-organic system combinations provided the best protection to the steel panel. In the following discussion the protective characteristics of the manufacturer's organic systems are compared to these same properties of the Navy vinyl system for each of the inorganic zinc coatings tested.

Systems 128 and 129

System 128 consisted of a self-cured zinc inorganic silicate primer topcoated with a coal tar-epoxy finish, while System 129 was the same primer topcoated with the Navy vinyl system.

At the beginning of the test period (after 5 years of exposure), System 128 was still showing only very light rusting and light to moderate blistering (with and without rusting) in all three zones. Deterioration did not progress further until the 8-year exposure period, when rusting was slightly more severe. After 11 years of exposure, this system was approaching failure and was rated 9,8,8.

System 129, the same zinc inorganic silicate as System 128 but topcoated with the Navy vinyl system, was providing slightly better protection than System 128, particularly in the tidal zone. This system was providing complete protection to the steel panel through the 6-year exposure period. Although it showed light to moderate blistering at the 6-year point and some of the blisters had ruptured, there was no rusting. With continued exposure, loss of system protection with rusting occurred and after 10 years of exposure, there was light galvanic corrosion in zone c. At the conclusion of the investigation (11 years), System 129 was providing good protection to the panel and was rated 9,10,8.

Systems 130 and 131

Systems 130 and 131 consisted of a post-cured zinc inorganic silicate primer, topcoated with the manufacturer's epoxy system and the Navy vinyl system, respectively.

Both of these systems had provided complete protection to the steel substrate through the 6-year exposure period. The only coating deterioration observed was light to medium dense blistering in the immersed zone. Very light rusting was first observed on both systems after 7 years of exposure and this became more severe with continued exposure. Rusting was more severe along the edges of System 131. Light fouling damage was also observed on both systems after seven years of exposure. In these cases, the organic coatings were removed from the zinc primer by barnacle attachment. After 11 years of exposure, the company epoxy topcoat (System 130) was performing better than the Navy vinyl system (System 131). System 130 was rated 9,9+,9+, while System 131 was rated 9,9,8.

Systems 132 and 133

Systems 132 and 133 were comprised of the manufacturer's epoxy coating and the Navy vinyl, respectively, applied over a self-cured zinc inorganic silicate primer. These two systems exhibited different performance characteristics in the initial exposure years with the Navy vinyl topcoated system (System 133) performing quite a bit better than System 132. This latter system was nearing failure after 5 years of exposure and was rated 10-,8,7, while System 133 was rated 10,9,9 at that time. With continued exposure both systems maintained about the same degree of protection with only a slight increase in their deterioration. During this period, these systems did show moderate to heavy edge rusting and undercutting by rust in all three zones. Although blistering was not heavy, many of the blisters ruptured resulting in loss of the zinc primer and pitting of the steel substrate in zones b and c. System 133 had failed (degrading rapidly between 9 and 10 years of exposure) by the conclusion of the 10-year exposure period, was rated 9,8,6, and was removed from test. System 132 was not considered to have failed until the 11-year exposure period at which time it was rated 9,7,7 and was removed from test.

Systems 134 and 135

These two systems represented a proprietary vinyl (System 134) and the Navy vinyl (System 135) topcoated over a post-cured zinc inorganic silicate.

Both of these vinyl systems exhibited medium to medium-dense blistering after 5 and 6 years of exposure. By the end of the 7- (System 134) and 9-year (System 135) exposure periods, most blisters had ruptured exposing the zinc primer. The exposed zinc subsequently corroded, permitting light rusting of the steel substrate. Such degradation also led to pitting in zones b and c and galvanic corrosion in zone c. Both of these systems have shown similar performance characteristics, although the manufacturer's vinyl system (System 134) was performing slightly better than the Navy vinyl at the conclusion of the exposure period. After 11 years of exposure, System 134 was rated 9,9,8 while System 135 was rated 9,8,7.

System 136

An epoxy coating, System 136* was the remaining organic coating applied over this particular self-cured zinc inorganic silicate coating. System 136 performed relatively well through 7 years of exposure, when it was rated 9,9,9. This system gradually deteriorated over the ensuing 4 years, exhibiting heavy pitting and undercutting in zone a and light galvanic corrosion in zone c. After 11 years of exposure, the performance of this system was rated 5,9,8; the system was considered to have failed, and was removed from test.

Systems 138 and 139

Systems 138 and 139 consisted of the manufacturer's recommended epoxy system and the Navy vinyl system, respectively, over a self-cured zinc inorganic silicate primer. Although these two systems had performed in a similar manner during their initial exposure period [1], differences in their performance became obvious with continued exposure. System 138 performed better than System 139 in the atmospheric zone, similar in the tidal zone, and poorer in the immersed zone. Both showed a high degree of edge rusting in zones b and c and galvanic corrosion in zone c. System 138 exhibited loss of adhesion and flaking of the epoxy in zones b and c as well as fouling damage in zone c. After 11 years of exposure, System 138 was rated 10,9,7 and System 139 was rated 8,8,8.

Systems 140 and 141

System 140 consisted of an aluminum-pigmented/hydrocarbon-resin system applied over a self-cured zinc inorganic silicate primer, and System 141 was the Navy vinyl applied over the same primer. The zinc primer was a single-package coating; that is, the zinc was premixed with the vehicle. As a result, the zinc pigment agglomerated to a certain extent and could not be completely redispersed. This caused the primer to have a bumpy, "orange-peel" finish.

Much of the relatively soft aluminum-pigmented/hydrocarbon-resin topcoat of System 140 had been removed from the primer in zones b and c by the end of the first 4 years of exposure [1]. However, the system primer and the zinc inorganic silicate provided very good protection to the steel substrate through 6 years of exposure. Continued exposure caused additional loss of this topcoat in zones b and c through blistering and abrasion. This resulted in galvanic corrosion along the edges of zone c, general rusting in zones b and c, and pinpoint rusting in zone a. After 10 years of exposure, much of the zinc had been consumed, the performance of the system was rated 9,8,5, and the panel was removed from test.

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*System 137 had failed after 4-years of exposure [1].

This same zinc inorganic silicate topcoated with the Navy vinyl system (System 141) was less effective than System 140 at the conclusion of the 5-year exposure period. However, continued deterioration of the system occurred relatively slowly. Deterioration with this system resulted, at least in part, from poor adhesion of the vinyl system to this single-package zinc inorganic silicate. This poor adhesion caused blistering, peeling, and flaking of the vinyl system in zones b and c. Loss of the vinyl system in zone c eventually caused severe rusting and pitting. After 11 years of exposure, this system was nearing failure and was rated 10-,8,6.

Systems 142 and 143

These two systems were comprised of the same two organic systems as used in Systems 140 and 141; that is, on aluminum-pigmented/hydrocarbon-resin (System 142) and the Navy vinyl (System 143), each applied over a post-cured zinc inorganic silicate primer.

The performance of Systems 142 and 143 was not a great deal different from that of Systems 140 and 141. The aluminum-pigmented/hydrocarbon-resin system performed less effectively over the post-cured silicate (System 142) than over the self-cured zinc primer (System 140). The Navy vinyl system, on the other hand, performed better when applied over the post-cured zinc primer than over the self-cured zinc inorganic silicate. The most striking difference between these systems over the self-cured and post-cured silicate primers was the total absence of blistering with the systems applied over the latter primer. The soft aluminum-pigmented/hydrocarbon-resin was abraded from the zinc primer (System 142) by floating debris. System 142 also exhibited progressively heavier rusting in zones b and c, including pinpoint rusting in zone c and galvanic corrosion along the edges. After 9 years of exposure, the system had failed, was rated 10,7,7, and was removed from test.

The performance of the vinyl system over the post-curing zinc inorganic silicate (System 143) did not change between the fourth year and the eleventh (final) year of exposure. During this 8-year period, the system performed very well and was rated 9,9,9 at each of the exposure periods. Deterioration occurred principally along edges where moderate to heavy edge rusting occurred.

System 144

This Navy vinyl was the test standard for this series and was the same system as that used over the zinc inorganic silicate primers. However, in System 144, the vinyl system was applied directly to sandblasted steel.

This system showed serious adhesion problems, particularly in the tidal zone. This was attributed, at least in part, to fouling damage in which barnacles removed the vinyl from the steel panel. Where the coating had been removed, the steel substrate had rusted. After 8 years of exposure, this system had failed with a performance rating of 8,7,7 and was removed from test.

Summary of Series 6

All of the combination systems (organic coating systems over zinc inorganic silicate primers) still exposed during this final period provided protection to the simulated steel piling that was superior to the Navy vinyl system applied directly to sandblasted steel (System 144), the test standard for this series. As mentioned above, adhesion of the organic systems to the zinc inorganic silicate primers can be a problem. While this was true in some cases, the poor adhesion characteristics of the Navy vinyl system in the test standard (System 144) was largely responsible for its early failure.

As a group, these combination systems exhibited very good to relatively poor protective properties (see Figure 1). All systems showed at least some deterioration during the 11 years of exposure. The best performance was provided by System 130, an epoxy topcoated post-cured zinc inorganic silicate system. This system showed only light deterioration in all three zones and was rated 9,9+,9+ at the conclusion of the 11-year test period. The next best performer was System 143, the Navy vinyl system also over a post-cured zinc inorganic silicate coating. This system was unusual because, although it showed early initial deterioration after only 1-1/2 years of exposure, its performance did not change appreciably during this 8-year exposure period. After 11 years of exposure, this system was rated 9,9,9. The next best system was System 129, Navy vinyl over a self-cured zinc inorganic silicate primer (rated 9,10,8). It is interesting to note that two Navy vinyl systems and two post-cured zinc inorganic silicate materials were in these top three systems. This suggests that the Navy vinyl system has an advantage over the manufacturer's recommended system and that the post-cured zinc inorganic silicate systems perform somewhat better than the self-cured zinc inorganic silicates. Such an assessment may not be completely valid because there are often rather subtle differences between the performance ratings of many of the systems. Other than the top two systems (Systems 130 and 143), all other systems had one or more zones that were rated 8 or less. Of the five systems that failed during this exposure period, four (Systems 132, 133, 136, and 140) contain self-cured zinc inorganic silicate primers and only one had a post-cured zinc inorganic silicate (System 142). On the other hand, four of the failures utilized company-recommended topcoats.

Failure of these combination systems had many similarities. Generally, loss of adhesion of the organic system from the zinc primer occurred either through blistering, peeling, or flaking. This was followed by corrosion of the zinc metal in the primer and corrosion of the steel substrate, undercutting, galvanic corrosion, and pitting. Of the three zones, the atmospheric zone showed the best performance. This corroborates the findings on unscribed panels of these same systems that were exposed to a marine atmosphere [6]. In this latter case, the biggest majority of these systems on unscribed steel panels in a marine atmosphere performed very well over a 5-year exposure period.

SERIES 7 - POLYESTER COATINGS

This series consisted of four different catalyzed polyester coatings, both unfilled and filled with fiberglass or flakeglass, that were applied by manufacturer-authorized applicators. Systems 145 and 145a are identical except for coating thickness. Systems 146 and 146a and Systems 147 and 147a are identical in all respects within each system number. System 148 contains no glass while System 148a contains fiberglass. These two panels varied slightly in thickness. The fiberglass-filled polyester coatings were Systems 145, 145a, and 148a; Systems 146, 146a, 147 and 147a were filled with flakeglass.

Systems 145 and 145a performed extremely well, providing complete and total protection to the steel substrate for the 9-year exposure period. This degree of protection is not surprising considering the thickness of the two coatings; 150 mils for System 145 and 85 mils for System 145a. Both of these fiberglass systems were considerably thicker than the flakeglass-filled polyesters, Systems 146 and 146a. These latter systems were identical and were both 50 mils thick. Systems 146 and 146a also performed extremely well throughout the 9-year exposure period. The only deterioration noted on either of these two systems was light rusting in zone b of System 146 where the coating had been mechanically damaged by floating debris. This permitted rusting to develop between the 6 and 9-year exposure periods. After 9 years of exposure, System 146 was rated 10,9,10. Had System 146 not been damaged mechanically, it appears as though it would have provided complete protection to the panel as the identical System 146a did.

Flakeglass-filled polyester Systems 147 and 147a were identical and both were 45 mils thick. These two systems performed similarly, providing relatively good protection to the steel substrate. Primary deterioration was attributed to light mechanical damage in zones a and b caused by floating debris. This resulted in rusting in these areas. After 9 years of exposure, System 147 was rated 9,9+,10 while System 147a was rated 9,9,10.

System 148 (8.5 mils) was the only polyester system without fiberglass or flakeglass reinforcing. System 148a (10.5 mils) was the same polyester with fiberglass reinforcing. Both of these are only 10% to 20% the thickness of most of the other polyester systems in the series. This lower thickness was largely responsible for their poorer performance. After 9 years of exposure, both were nearing failure, with System 148 rated 7,8,8 and System 148a rated 6,8,8. Both systems had mechanical damage and rusting along the edges while System 148 also had pinpoint rusting in zones a and b. In addition, System 148a exhibited cracking of the polyester coating along the edges in the tidal and immersed zones and showed fouling damage, also along the edges. System 148a was the only system in the series that exhibited blistering.

Summary of Series 7 Coatings

In general, the polyester coatings performed quite well (see Figure 1). However, much of the good performance can be attributed to the excessive

thickness of these systems. Because the fiberglass-filled systems were generally so much thicker than the flakeglass-filled polyesters, it is not possible to draw valid conclusions as to which type of glass might give a superior coating system.

Catalyzed polyesters can become quite brittle and can also develop stresses due to the high exotherms that are often generated during the curing process. Such stresses can cause weakening of the bond between the coating and the steel [6]. Because of these factors, it is not surprising that the polyesters were subject to damage by floating debris. In spite of the rusting that resulted from the mechanical damage, no undercutting of the surrounding polyester was observed. This is contrary to the results obtained in an atmospheric exposure of these same coatings where scribed panels exhibited severe undercutting after only 2 years of exposure [6].

SERIES 8 – TOPCOATED ZINC-FILLED EPOXIES

This series of coatings consisted of five zinc-filled epoxy primers that were topcoated with an aluminum vinyl, a vinyl mastic, saran (Formula 113/54), and the manufacturer's recommended system. The primers consisted of the following: two 1-package zinc-rich epoxies which cured by solvent evaporation (Systems 149 through 152 and Systems 161 through 164); one 2-package amine-cured epoxy in which the zinc pigment was incorporated in the resin component (Systems 153 through 156); one 2-package polyamide-cured epoxy with the zinc pigment incorporated in the resin component (Systems 165 through 168); and one 3-package coating in which the polyamide curing agent, the epoxy resin, and the dry zinc pigment were all packaged separately (Systems 157 through 160). As with the zinc inorganic silicate primers, it was necessary to continuously stir the zinc-rich epoxies during application in order to keep the zinc pigment suspended. A saran coating, System 169, was the control for this series.

Aluminum-Pigmented Vinyl Topcoats

The aluminum vinyl topcoated zinc primers – Systems 151, 155, 159, 163, and 167 – provided very good to excellent protection to the steel substrate, with one exception. The exception, System 163, contained one of the single package epoxy primers. Even this system performed relatively well until between 7 and 8 years of exposure, at which time much of the organic topcoat had been removed from the zinc primer, permitting the zinc to be consumed. As the zinc was removed, the steel substrate rusted and after 9 years of exposure, this system was nearing failure and was rated 9,8,7. System 163 showed the poorest performance of any of the aluminum vinyl systems in this group.

System 151, on the other hand, provided complete protection to the simulated steel piling, exhibiting little or no deterioration of any kind. This system was also a single package zinc-filled epoxy primer. Systems 155, 159, and 167 provided very good protection to the steel panels and after 9 years of exposure were rated 9,9,9; 10-9,9; and

9,10,10; respectively. System 163 performed less effectively than the saran standard, System 169, while System 155 was equivalent, and Systems 151, 159, and 167 were superior to the standard. The primary deterioration was caused by fouling damage which removed the aluminum-pigmented vinyl system from the zinc primer, permitting the zinc to be consumed and the steel substrate to rust.

Vinyl Mastic Topcoats

As a group, the vinyl mastic topcoated zinc-filled epoxy primers performed about the same as the aluminum pigmented vinyl group. Of this group (consisting of Systems 150, 154, 158, 162, and 166), System 154 showed the lowest degree of protection. However, even this latter system was performing well after 9 years of exposure and was rated 9,9,8. At the conclusion of the investigation, the remaining four systems were performing very well showing only slight differences in their protective qualities. After 9 years, Systems 150, 158, 162, and 166 were rated 10,9+,9+; 9+,9,9+; 10-,9,9; and 10,9,10; respectively. At that time, Systems 150, 162, and 166 were providing protection to the steel substrate that was superior to the saran standard, System 169; System 158 was providing equivalent protection; and System 154 was slightly less effective than the saran standard. In each of the systems in this group, the primary deterioration was caused by fouling damage where barnacles had removed the vinyl mastic topcoat from its zinc primer.

Saran

The protection provided by the group of saran topcoated, zinc-filled epoxies (Systems 152, 156, 160, 164, and 168) was slightly less effective than that shown by the aluminum-pigmented vinyls and the vinyl mastics. This is probably due in part to the fact that the saran systems were from 2 to 7 mils lower in dry film thickness than either the aluminum-vinyl or vinyl-mastic systems.

The best performance in this group was shown by System 160, saran over a 3-package zinc-rich epoxy primer. After 9 years of exposure suspended from the corrosion dock, this system was providing almost complete protection to the steel panel. The only deterioration was very light pinpoint rusting in zone a which was first observed at the 6-year exposure period. The poorest performer in this group was System 164, saran over one of the single package zinc-primers. However, with a 9-year protection rating of 9,8,9 this system was still providing relatively good protection to the steel panel.

The other three systems in this group, Systems 152, 156, and 168 were all providing about the same degree of protection after 9 years of exposure and were rated 9,9,9; 9,9,9+; and 9+,9,9+; respectively. Thus, the performance of these three systems was equivalent to the saran standard, System 169, while System 160 was superior to and System 164 less effective than this standard. Primary deterioration of these systems appeared to be light pinpoint rusting in zone a, and light fouling damage in zones b and c, which occurred toward the end of the exposures.

Manufacturer's Recommended Topcoats

The manufacturer's recommended topcoats consisted of two epoxies, Systems 153 and 165; two coal-tar/epoxies, Systems 149 and 157; and one alkyd topcoat, System 161. All of them were applied over their respective zinc-filled epoxy primers. As a group, these systems provided poorer protection to the steel panels than any of the other groups in this series. This poorer performance can be attributed to the poor showing of System 161, the alkyd topcoat, which was the only system in this series that failed. After 9 years of exposure, this system was rated 9,7,5 and was removed from the test. Alkyd systems are not normally recommended for immersion in seawater because their performance in such an environment leaves much to be desired. As might have been expected, the alkyd system exhibited poor adhesion characteristics which made it particularly susceptible to fouling damage and damage by floating debris. After much of the alkyd had been removed in zones b and c, the zinc was consumed and general rusting, galvanic corrosion, and pitting were observed.

The best performance in this group was shown by System 157, a coal tar-epoxy applied over the three-part zinc primer. This system showed very little deterioration and after 9 years of exposure was rated 9+,10,10. The second coal tar-epoxy (System 149) was only slightly less effective than System 157 and was rated 10,9,9 after 9 years.

The last two systems in this group (Systems 153 and 165) were both epoxy topcoats and showed similar performance characteristics. After 9 years of exposure, System 153 was rated 9,9,9 while System 155 was rated 8,9,9. Deterioration of these two systems resulted from blistering of the topcoat, mechanical damage, and light pitting. Systems 149 and 157 showed superior performance compared to the saran standard, System 169, while System 153 was equivalent, and Systems 161 and 165 were less effective than the standard.

Summary of Series 8 Coatings

It has already been pointed out that, when compared according to topcoat groups, the aluminum-pigmented vinyls, the vinyl mastics, and the sarans are slightly superior to the manufacturer's recommended topcoats. This is shown graphically in Figure 1. A comparison of the bar graphs for the aluminum-pigmented vinyls, the vinyl mastics, and the sarans in Figure 1 does not indicate a great deal of difference in performance of these three different topcoats. A study of the ratings for the 9-year exposure period shows only slight differences between these groups. The aluminum-pigmented vinyls and vinyl mastics performed similarly, but they were only slightly better performers than the saran topcoat. As mentioned earlier, this may be attributed to the lesser dry film thickness of the saran systems.

It is interesting also to compare the five different zinc-filled epoxies as groups; that is, the two single-package, two 2-package, and one 3-package primers. With the exception of the vinyl mastic group (System 162), one of the single-package zinc-filled epoxy primers was

the poorest performer when topcoated with the other three topcoats (Systems 161, 163, and 164). This zinc primer was, in fact, the primer of the only system that failed in this series, System 161. Also, the topcoat on this system was an alkyd, and alkyds normally perform poorly in a marine environment. It is not at all clear why this single-package zinc primer topcoated with the vinyl mastic performed as well as it did. The poor performance of this group of topcoated single-package epoxies cannot be attributed to the fact that it was a single-package material since the group using the other single-package material (Systems 149 through 152) performed quite well. All the 3-package epoxies (Systems 157 through 160) and the 2-package polyamide-cured epoxies (Systems 165 through 168) performed quite well and about equally. The amine-cured epoxy group (2-package, Systems 153 through 156) also performed well but were slightly less effective than the three mentioned above.

A study of Figure 1 and the ratings in Appendix B suggests that, as a group, the organic topcoated zinc-filled epoxy (Series 8) systems, have performed slightly better than the organic-topcoated zinc inorganic silicate systems (Series 6). This is attributed, at least in part, to the fact that organic coatings generally adhere better to the zinc-filled organic primers than to the zinc inorganic silicate primers.

FINDINGS AND CONCLUSIONS

Based on results of tests of coating systems applied to 10-foot simulated steel pilings exposed in Port Hueneme Harbor for periods up to 21-1/2 years, it is concluded that:

1. The following coating systems exposed in a harbor environment can be expected to provide good to excellent protection for periods of 15 to 20 years:

   a. Saran applied by brush (System 10)

   b. Phenolic mastic coatings (Systems 36, 37, and 72)

   c. Flame-sprayed aluminum (Systems 13 and 84)

   d. Combination systems of saran (System 18); Navy vinyl, Formula 119 (System 22); and a polyamide-cured epoxy (System 42) - each applied over flame-sprayed zinc

   e. Coal tar-epoxies (Systems 87 and 103)

   f. Epoxy (System 101)

   g. Aluminum pigmented vinyl (System 106)

All of the above systems have exhibited protective properties that are considered superior to those of the saran standard (System 16)*. System 103, a coal tar-epoxy was particularly effective, showing only light blistering (no rusting) for 16 years of exposure.

2. The following coating systems can be expected to provide good to excellent protection and performance superior to the saran standard (System 16) in a harbor environment for periods of 12-1/2 to 14-1/2 years:

a. Coal tar-epoxies (Systems 117 and 118)

b. Epoxies (Systems 116 and 123)

c. Vinyl (System 115)

These and other systems considered below have not yet been exposed long enough to determine which will perform acceptably for 15 to 20 years. They cannot yet be compared with those discussed in conclusion 1.

3. Of the four surface treatments investigated in Series 2 (that is, sandblasted steel, sandblasted steel with Formula 117, sandblasted steel with flame-sprayed aluminum, and sandblasted steel with flame-sprayed zinc), the best systems were based on flame-sprayed zinc as a primer.

4. All of the topcoated zinc inorganic silicate systems exhibited protective properties superior to the standard Navy vinyl-alkyd system (System 144). The following combination systems can be expected to provide good to excellent protection in a harbor environment for periods up to 11 years:

a. Coal tar-epoxy (System 128)

b. Epoxy (System 130)

c. Vinyl (System 134)

d. Vinyl-alkyd (Systems 129, 131, and 143)

In general, the Navy vinyl-alkyd system performed equal to or better than the manufacturer's recommended system when used as a topcoat for the zinc inorganic silicate primers. Application of Formula 117 pretreatment primer over the zinc inorganic silicate coatings is desirable prior to topcoating with the remainder of the Navy vinyl system.

5. Fiberglass- or flakeglass-reinforced polyester coating systems can provide complete protection in a harbor environment for periods up to 9 years when the coatings are in excess of a 50-mil dry film thickness. Both types of glass-filled polyesters are subject to damage by floating debris.

6. The following topcoated zinc-filled epoxy primers provided protection that was superior to the saran standard (System 169) and can be expected to provide very good to excellent protection to steel piling in a harbor environment for periods up to 9 years:

*This material is no longer available.

a. Aluminum-pigmented vinyl (Systems 151, 159, and 167).

b. Vinyl mastic (Systems 150, 162, and 166).

c. Saran (System 160).

d. Manufacturer's recommended topcoats - coal tar-epoxies (Systems 149 and 157).

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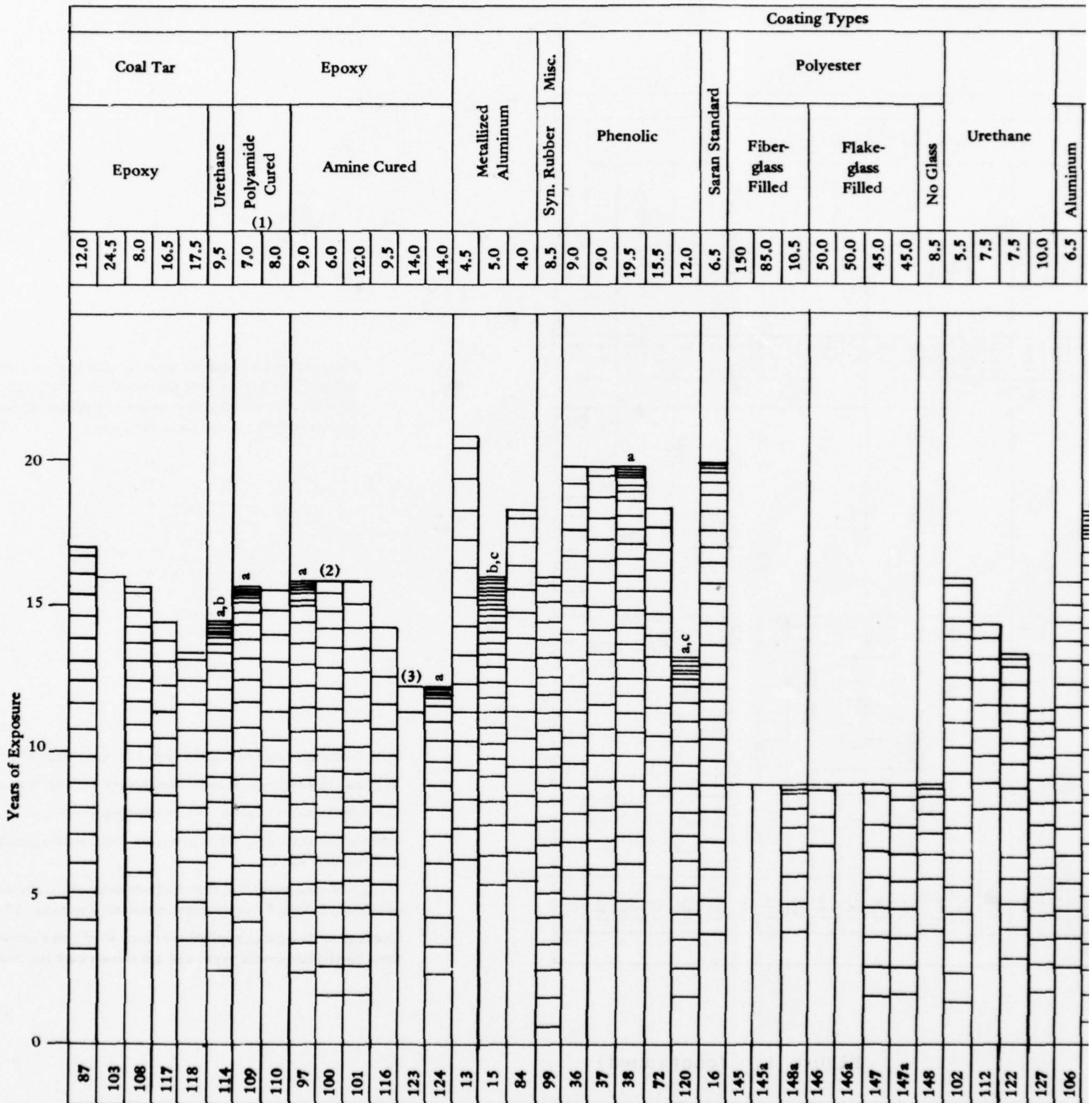

Figure 1. Comparative protection provided to corrosion dock panels by th

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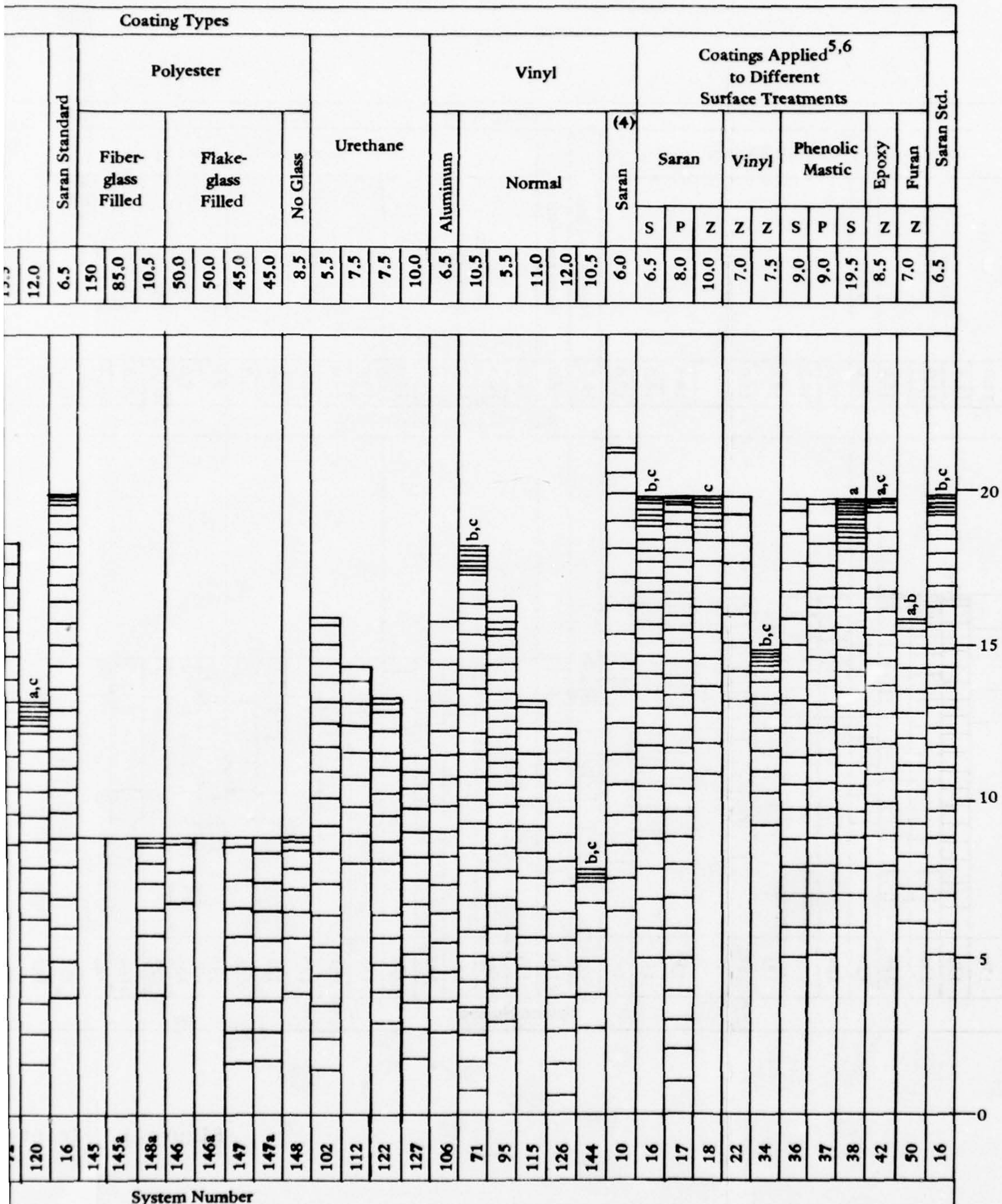

ided to corrosion dock panels by the various coating systems.

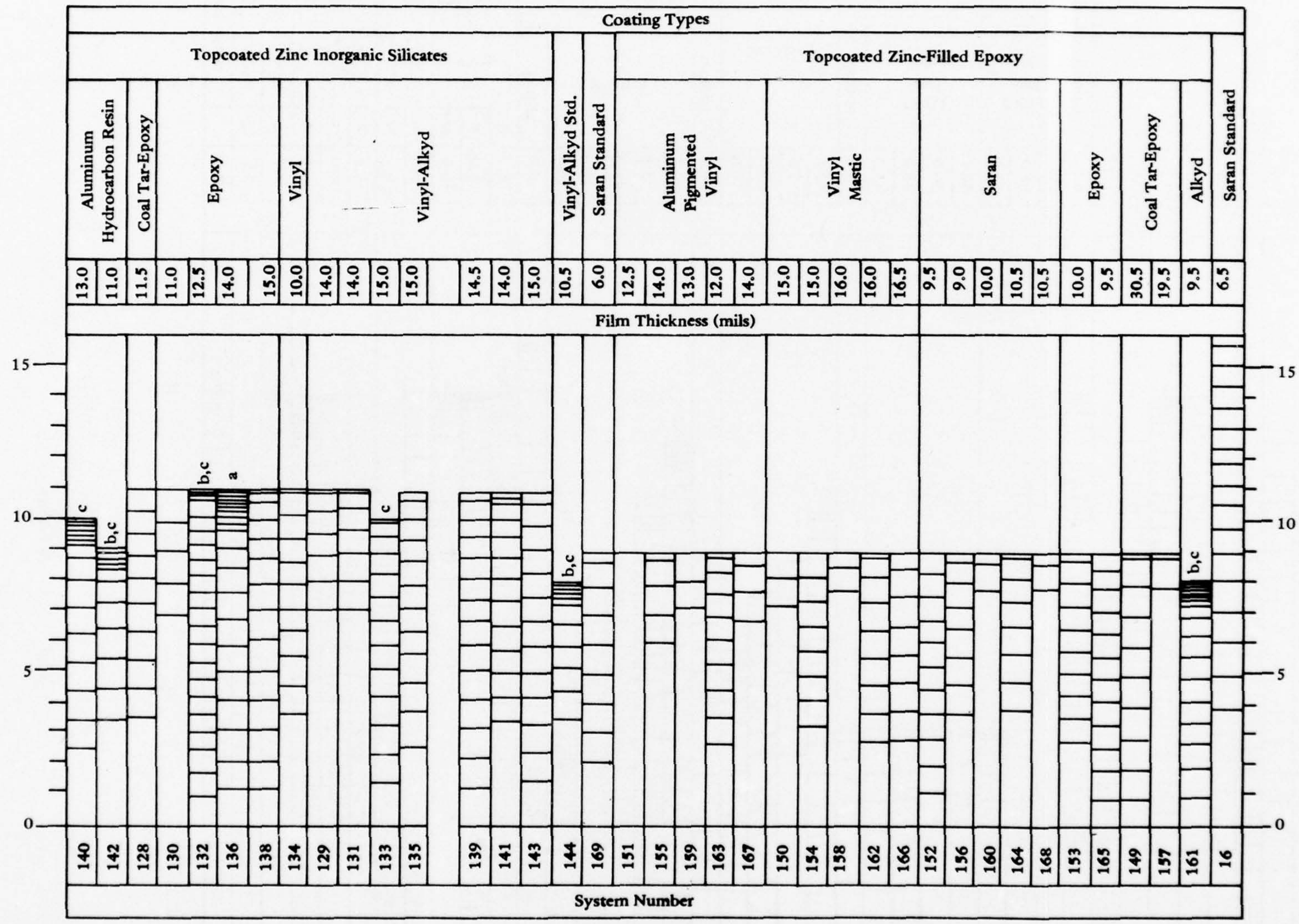

Figure 1. (continued)

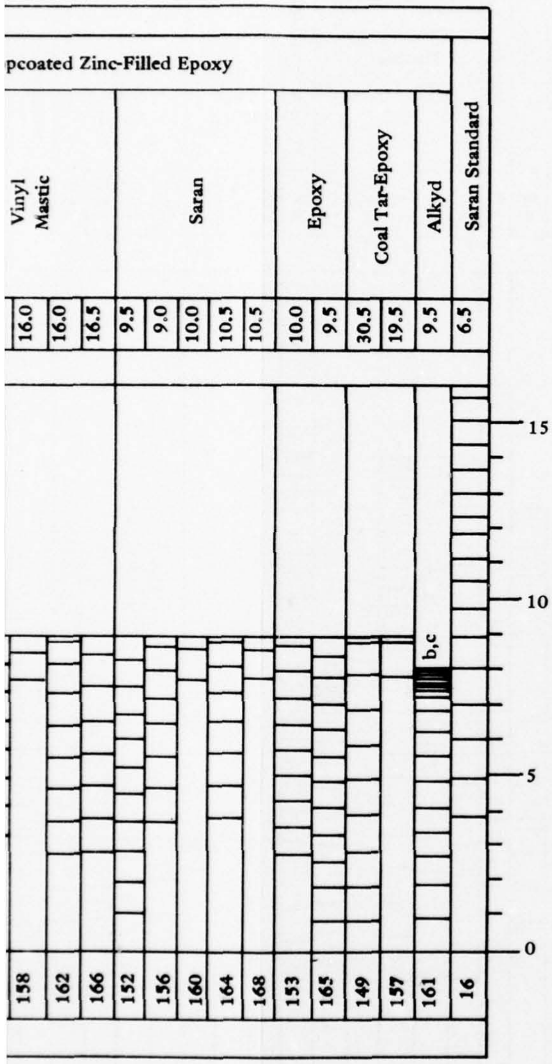

Figure 1. (continued)

(Complete protection denoted by outlined bar; initial system deterioration indicated by line nearest the baseline of the graph. As system deteriorates, lines become progressively closer together until they coalesce at failure and removal of the system from exposure.)

1 TFE (Tetrafluoroethylene), System 110, is System 109 with the TFE emulsion finish.

2 This was an amine-cured zinc-filled epoxy without topcoat.

3 The vehicle of the topcoat was an epoxy-phenolic.

4 Saran is not actually a vinyl, but is included in this group since its properties are similar to those of a vinyl.

5 The letters designate different surfaces over which the coatings were applied. S = bare sandblasted steel; P - pretreatment primer, Formula 117; Z = flame-sprayed zinc.

6 Coatings in this group applied over bare steel and Formula 117 are also included under their particular generic types and are shown here for comparison.

Appendix A

SYSTEM DESCRIPTION FOR COATINGS EXPOSED ON CORROSION DOCK

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 1			
10	Saran (orange)			6.0
	Saran (alternate white and orange coats)	5	6.0	
13	Flame-sprayed aluminum (aluminum)			4.5
	Flame-sprayed aluminum powder	1	4.5	
15	Flame-sprayed aluminum (aluminum)			5.0
	Flame-sprayed aluminum wire	1	5.0	
	Series 2			
16	Saran (white)			6.5
	Saran (Formula 113/49), alternate orange and white coats	7	6.5	
17	Saran (white)			8.0
	MIL-C-15328 (Formula 117), pretreatment primer	1	0.5	
	Saran (Formula 113/49), alternate orange and white coats	8	7.5	
18	Saran (white)			10.0
	Flame-sprayed zinc wire	1	2.5	
	Saran (Formula 113/49), alternate orange and white coats	7	7.5	
22	Vinyl (orange)			7.0
	Flame-sprayed zinc wire	1	2.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	5	4.5	
34	Vinyl (gray)			7.5
	Flame-sprayed zinc wire	1	2.5	
	Vinyl finish	5	5.0	
36	Phenolic mastic (gray)			9.0
	Catalyzed phenolic mastic primer	1	4.5	
	Catalyzed phenolic mastic finish	1	4.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 2 (continued)			
37	Phenolic mastic (gray)			9.0
	MIL-C-15328 (Formula 117), pretreatment primer	1	0.5	
	Catalyzed phenolic mastic primer	1	4.5	
	Catalyzed phenolic mastic finish	1	4.0	
38	Phenolic mastic (gray)[a]			19.5
	Catalyzed mica-filled phenolic mastic primer	1	11.0	
	Catalyzed phenolic mastic finish	1	8.5	
42	Epoxy (white)			8.5
	Flame-sprayed zinc wire	1	3.0	
	Catalyzed epoxy finish	2	5.5	
50	Furan (gray)			7.0
	Flame-sprayed zinc wire	1	3.0	
	Furan finish	3	4.0	
	Series 4			
71	Vinyl mastic (black)			10.5
	Vinyl–phenolic strontium chromate, iron oxide primer	1	1.5	
	Vinyl mastic finish	2	9.0	
72	Phenolic mastic (gray)			15.5
	Catalyzed mica-filled phenolic mastic primer	1	10.5	
	Catalyzed phenolic mastic finish	1	5.0	
84	Flame-sprayed aluminum (aluminum)			4.0
	MIL-M-3800 aluminum wire, flame-sprayed	1	4.0	
	Series 5			
87	Coal tar–epoxy (black)			12.0
	Catalyzed coal tar–epoxy	3	12.0	
95	Vinyl (gray)			5.5
	Aluminum-pigmented vinyl–thiokol primer	3	2.5	
	Vinyl finish	2	3.0	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
Series 5 (continued)				
97	Epoxy (gray)			9.0
	Catalyzed epoxy primer	1	1.5	
	Catalyzed epoxy body coat	2	3.5	
	Catalyzed epoxy finish	2	4.0	
99	Chlorosulfonated polyethylene (gray)			8.5
	Vinyl red-lead, iron oxide primer	2	1.5	
	Catalyzed chlorosulfonated polyethylene finish	5	7.0	
100	Zinc-filled modified epoxy (gray)			6.0
	Catalyzed zinc-filled modified epoxy	3	6.0	
101	Epoxy (gray)			12.0
	Catalyzed epoxy primer	1	3.0	
	Catalyzed epoxy finish	2	9.0	
102	Aluminum-pigmented urethane (aluminum)			5.5
	Catalyzed urethane red-lead primer	2	1.5	
	Catalyzed urethane intermediate	1	1.5	
	Catalyzed aluminum-pigmented urethane finish	4	2.5	
103	Aluminum-pigmented coal tar—epoxy (aluminum)			24.5
	Catalyzed coal tar—epoxy red-lead primer	1	7.5	
	Catalyzed coal tar—epoxy intermediate	2	14.5	
	Catalyzed aluminum-pigmented coal tar—epoxy finish	1	2.5	
106	Aluminum-pigmented vinyl (aluminum)			6.5
	Pretreatment primer	1	0.5	
	Vinyl red-lead primer	2	1.5	
	Aluminum-pigmented vinyl finish	3	4.5	
108	Coal tar—epoxy (black)			8.0
	Catalyzed coal tar—epoxy	2	8.0	
109	Epoxy (cream)			7.0
	Catalyzed epoxy primer	1	1.0	
	Catalyzed epoxy intermediate	1	2.5	
	Catalyzed epoxy finish	1	3.5	
110	Tetrafluoroethylene (blue-green)			8.0
	Catalyzed epoxy primer	1	1.5	
	Catalyzed epoxy intermediate	1	2.0	
	Catalyzed epoxy finish	1	4.0	
	Tetrafluoroethylene emulsion finish	1	0.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
Series 5 (continued)				
112	Urethane (green)			7.5
	Vinyl red-lead, iron oxide primer	1	2.5	
	Catalyzed urethane finish	2	5.0	
114	Coal tar—urethane (black)			9.5
	Catalyzed coal tar—urethane finish	2	9.5	
115	Vinyl (gray)			11.0
	Pretreatment primer	1	0.5	
	Vinyl iron oxide primer	1	2.0	
	Vinyl finish	2	8.5	
116	Epoxy (gray)			9.5
	Catalyzed epoxy zinc chromate primer	1	4.5	
	Catalyzed epoxy finish	2	5.0	
117	Coal tar—epoxy (black)			16.5
	Catalyzed coal tar—epoxy finish	3	16.5	
118	Coal tar—epoxy (black)			17.5
	Catalyzed coal tar—epoxy finish	3	17.5	
120	Modified phenolic (gray)			12.0
	Catalyzed modified phenolic primer	1	6.0	
	Catalyzed modified phenolic finish	2	6.0	
122	Urethane (gray)			7.5
	Catalyzed urethane zinc chromate primer	1	1.0	
	Catalyzed urethane finish	7	6.5	
123	Epoxy phenolic (gray)			14.0
	Catalyzed epoxy primer	1	3.0	
	Catalyzed epoxy—phenolic finish	3	11.0	
124	Epoxy (white)			14.0
	Catalyzed epoxy zinc chromate primer	1	3.5	
	Catalyzed epoxy finish	1	10.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 5 (continued)			
126	Vinyl (black)			12.0
	MIL-C-15328A (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929A (Formula 119), vinyl red-lead primer	5	6.5	
	MIL-E-15932A (Formula 122-1), vinyl—alkyd finish	2	5.0	
127	Urethane (black)			10.0
	Catalyzed epoxy zinc chromate primer	1	2.5	
	Catalyzed urethane finish	3	7.5	
	Series 6			
128	Coal tar—epoxy (black)			11.5
	Zinc inorganic silicate (self-cured)	1	2.5	
	Catalyzed coal tar—epoxy finish	1	9.0	
129	Vinyl (gray)			14.0
	Zinc inorganic silicate (self-cured)	1	3.0	
	MIL-P-15328B (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	3	6.0	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	4.5	
130	Epoxy (gray)			11.0
	Zinc inorganic silicate (post-cured)	1	3.0	
	Catalyzed epoxy lead-silico-chromate primer	1	2.0	
	Catalyzed epoxy intermediate	1	4.0	
	Catalyzed epoxy finish	1	2.0	
131	Vinyl (gray)			14.0
	Zinc inorganic silicate (post-cured)	1	3.0	
	MIL-P-15328B (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	5	5.0	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	5.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 6 (continued)			
132	Epoxy (gray)			12.5
	Zinc inorganic silicate (self-cured)	1	5.0	
	Catalyzed epoxy mastic iron oxide and chromate primer	2	5.0	
	Catalyzed epoxy finish	1	2.5	
133	Vinyl (gray)			15.0
	Zinc inorganic silicate (self-cured)	1	4.0	
	MIL-P-15328B (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	3	5.5	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	5.0	
134	Vinyl (gray)			10.0
	Zinc inorganic silicate (post-cured)	1	2.0	
	Vinyl mastic iron oxide and chromate primer	1	1.5	
	Vinyl mastic intermediate	1	4.0	
	Vinyl finish	1	2.5	
135	Vinyl (gray)			15.0
	Zinc inorganic silicate (post-cured)	1	2.0	
	MIL-P-15328B (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	3	6.5	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	6.0	
136	Epoxy (gray)			14.0
	Zinc inorganic silicate (self-cured)	1	4.0	
	Catalyzed epoxy lead-silico-chromate primer	1	2.0	
	Catalyzed epoxy intermediate	1	5.0	
	Catalyzed epoxy finish	1	3.0	
138	Epoxy (gray)			15.0
	Zinc inorganic silicate (self-cured)	1	4.0	
	Acrylic zinc chromate, zinc oxide primer	1	1.0	
	Catalyzed epoxy finish	1	10.0	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 6 (continued)			
139	Vinyl (gray)			14.5
	Zinc inorganic silicate (self-cured)	1	3.5	
	MIL-P-15328B (Formula 117), pretreatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	3	6.5	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	4.0	
140	Aluminum-pigmented hydrocarbon resin (aluminum)			13.0
	Zinc inorganic silicate (self-cured)	1	3.0	
	Modified phenolic—epoxy red iron oxide tie coat	1	1.0	
	Aluminum-pigmented hydrocarbon resin finish	3	9.0	
141	Vinyl (gray)			14.0
	Zinc inorganic silicate (self-cured)	1	3.0	
	MIL-P-15328B (Formula 117), pretreatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	3	6.0	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	4.5	
142	Aluminum-pigmented hydrocarbon resin (aluminum)			11.0
	Zinc inorganic silicate (post-cured)	1	2.0	
	Modified phenolic—epoxy red iron oxide tie coat	1	1.0	
	Aluminum-pigmented hydrocarbon resin finish	3	8.0	
143	Vinyl (gray)			15.0
	Zinc inorganic silicate (post-cured)	1	2.5	
	MIL-P-15328B (Formula 117), pretreatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	4	6.0	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	6.0	
144	Vinyl (gray)			10.5
	MIL-P-15328B (Formula 117), pretreatment primer	1	0.5	
	MIL-P-15929B (Formula 119), vinyl red-lead primer	4	6.0	
	MIL-E-15936B (Formula 122-27), vinyl—alkyd finish	2	4.0	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 7			
145	Polyester (gray)			150
	Catalyzed fiberglass-filled polyester	4	150	
145a	Polyester (gray)			85
	Catalyzed fiberglass-filled polyester	4	85	
146	Polyester (white)			50
	Catalyzed flakeglass-filled polyester	3	50	
146a	Polyester (white)			50
	Catalyzed flakeglass-filled polyester	3	50	
147	Polyester (cream)			45
	Catalyzed flakeglass-filled polyester	3	45	
147a	Polyester (cream)			45
	Catalyzed flakeglass-filled polyester	3	45	
148	Polyester (white)			8.5
	Catalyzed polyester	3	8.5	
148a	Polyester (white)			10.5
	Catalyzed fiberglass filled polyester	3	10.5	
	Series 8			
149[b]	Coal tar–epoxy (black)			40.5 (top 1/3)
	Zinc-filled polyether[c]	2	3.0	30.5 (bottom 2/3)
	Catalyzed coal tar–epoxy finish	2	27.5	
	Bituminous emulsion finish	1	10.0	
150	Vinyl mastic (black)			15.0
	Zinc-filled polyether[c]	2	3.5	
	Vinyl–phenolic strontium chromate iron oxide primer	1	1.0	
	Vinyl mastic finish	3	10.5	
151	Aluminum-pigmented vinyl (aluminum)			12.5
	Zinc-filled polyether[c]	2	3.0	
	MIL-P-15328 (Formula 117), pretreatment primer	1	0.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	2	6.0	
	Aluminum-pigmented vinyl finish	2	3.0	
152	Saran (white)			9.5
	Zinc-filled polyether[c]	2	3.0	
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	4	6.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
	Series 8 (continued)			
153	Epoxy (gray)			10.0
	Catalyzed zinc-filled epoxy[d]	3	6.5	
	Catalyzed epoxy finish	2	3.5	
154	Vinyl mastic (black)			15.0
	Catalyzed zinc-filled epoxy[d]	1	3.5	
	Vinyl—phenolic strontium chromate iron oxide primer	1	1.0	
	Vinyl mastic finish	2	10.5	
155	Aluminum-pigmented vinyl (aluminum)			14.0
	Catalyzed zinc-filled epoxy[d]	1	5.5	
	MIL-P-15328 (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	2	5.0	
	Aluminum-pigmented vinyl finish	2	3.0	
156	Saran (white)			9.0
	Catalyzed zinc-filled epoxy[d]	1	3.0	
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	4	6.0	
157	Coal tar—epoxy (red)			19.5
	Catalyzed zinc-filled modified epoxy[e]	1	3.5	
	Catalyzed coal tar—epoxy finish	2	16.0	
158	Vinyl mastic (black)			16.0
	Catalyzed zinc-filled modified epoxy[e]	3	2.5	
	Vinyl—phenolic strontium chromate iron oxide primer	1	1.0	
	Vinyl mastic finish	3	12.5	
159	Aluminum-pigmented vinyl (aluminum)			13.0
	Catalyzed zinc-filled modified epoxy[e]	1	3.5	
	MIL-P-15328 (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	2	6.0	
	Aluminum pigmented vinyl finish	2	3.0	
160	Saran (white)			10.0
	Catalyzed zinc-filled modified epoxy[e]	1	3.5	
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	5	6.5	
161	Enamel (gray)			9.5
	Zinc-filled epoxy[c]	1	3.0	
	Alkyd enamel	3	6.5	

continued

System No.	System Components and Color	No. of Coats	Component Thickness (mils)	Total System Thickness (mils)
Series 8 (continued)				
162	Vinyl mastic (black)			16.0
	Zinc-filled epoxy[c]	1	2.5	
	Vinyl–phenolic strontium chromate iron oxide primer	1	1.0	
	Vinyl mastic finish	2	12.5	
163	Aluminum-pigmented vinyl (aluminum)			12.0
	Zinc-filled epoxy[c]	1	3.0	
	MIL-P-15328 (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	2	5.5	
	Aluminum-pigmented vinyl finish	2	3.0	
164	Saran (white)			10.5
	Zinc-filled epoxy[c]	1	4.0	
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	4	6.5	
165	Epoxy (gray)			9.5
	Catalyzed zinc-filled epoxy[d]	3	4.0	
	Catalyzed epoxy	2	5.5	
166	Vinyl mastic (black)			16.5
	Catalyzed zinc-filled epoxy[d]	3	4.0	
	Vinyl–phenolic strontium chromate iron oxide primer	1	1.0	
	Vinyl mastic finish	3	11.5	
167	Aluminum-pigmented vinyl (aluminum)			14.0
	Catalyzed zinc-filled epoxy[d]	2	4.5	
	MIL-P-15328 (Formula 117), pre-treatment primer	1	0.5	
	MIL-P-15929 (Formula 119), vinyl red-lead primer	2	6.0	
	Aluminum-pigmented vinyl finish	2	3.0	
168	Saran (white)			10.5
	Catalyzed zinc-filled epoxy[d]	2	4.5	
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	5	6.0	
169	Saran (white)			6.0
	MIL-L-18389 (Formula 113/54) saran, alternate orange and white coats	4	6.0	

[a] This system was not compatible with the flame-sprayed zinc coating and reacted chemically when applied as a topcoat. Consequently, the phenolic mastic was not tested over the flame-sprayed zinc wire.

[b] System 149 consisted of two coats of a zinc-filled polyether (3.0 mils) and two coats of catalyzed coal tar-epoxy (27.5 mils) over the entire panel length for total thickness of 30.5 mils. One coat of bituminous emulsion (10 mils) was then applied to the top one-third of the panel for total thickness of 40.5 mils in this zone.

[c] Single-package primer.

[d] Two-package primer.

[e] Three-package primer.

Appendix B

PERFORMANCE RATINGS FOR COATING SYSTEMS EXPOSED ON CORROSION DOCK

Footnotes a and b throughout the following series are defined as follows:

[a]The designations/D,(/)MD,/M, and/F denote the frequency of blistering: dense, medium dense, medium, and few.

[b]The designations/H,/MH,/M, and/L denote heavy, medium heavy, medium, and light fouling attachment, respectively.

Series 1

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
10	Saran (6 mil)	16-1/2	a	10	2/F	10	10	10	16-1/2 to 20-1/2 years – Pitting slightly heavier in zone c than in zone b. Blisters broken, very light. Type II rusting.
			b	9	2/F	10	9	4/L	
			c	8	2/M	10	8	8/L	
		17-1/2	a	10	2/F	10	10	10	
			b	9	2/M	10	9	6/L	
			c	8	2/F	10	8	6/L	
		18-1/2	a	10	2/F	10	10	10	
			b	8	2/M	10	8	5/L	
			c	8	2/F	10	8	8/L	
		19-1/2	a	10	2/F	10	10	10	
			b	8	2/M	10	8	4/L	
			c	8	2/D	10	8	7/L	
		20-1/2	a	10	2/F	10	10	10	
			b	8	2/F	10	8	8/L	
			c	8	2/F	10	8	8/L	
		21-1/2	a	10	2/F	10	10	L	
			b	8	2/F	10	8	L	
			c	7	2/F	10	7	L	
13	Flame-sprayed aluminum powder (4.5 mil)	16	a	10	10	10	10	10	16 to 19 years – Light pitting in zone c. 16 to 21 years – Area on top of zone a that had reduced protection rating to 9 (see Reference 1) had been repaired when hook replaced. Coating providing complete protection in zone a.
			b	9	10	9	10	4/L	
			c	9	10	9	10	6/L	
		17	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	6/L	
		18	a	10	10	10	10	10	
			b	9	10	9	10	2/L	
			c	9	10	9	10	8/L	

continued

Series 1 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
13 cont'd		19	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	8/L	
		20	a	10	10	10	10	–	
			b	9	10	9	10	–	
			c	9	10	9	10	–	
		21	a	10	10	10	–	–	
			b	9	10	9	–	L	
			c	9	10	9	–	L	
15	Flame-sprayed aluminum wire (5 mil)	16	a	9	10	9	10	10	16 years – Rusting very heavy in zone c; also galvanic corrosion in this area. 16 years system removed from test.
			b	5	10	5	10	2/L	
			c	2	10	2	10	4/L	
Series 2									
16	Saran (Formula 113/49 (6.5 mil)	15	a	9	2/F	9	9	10	
			b	9	2/M	9	9	4/H	
			c	7	2/MD	9	7	6/L	
		16	a	9	2/F	9	9	10	
			b	8	2/MD	8	8	4/L	
			c	7	2/MD	8	7	8/L	
		17	a	9	2/F	9	9	10	
			b	8	2/M	8	8	6/M	
			c	7	2/M	8	7	2/H	
		18	a	9	2/M	9	9	10	
			b	8	2/M	8	8	6/M	
			c	7	2/F	8	7	4/H	
		19	a	9	2/F	9	9	10	14 to 19 years – Light pitting, galvanic corrosion in zone c. Some undercutting along edges and around broken blisters.
			b	8	2/M	8	8	6/L	
			c	6	2/F	7	6	5/M	

continued

Series 2 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
16 cont'd		20	a	9	2/F	9	9	–	20 years – system removed from test.
			b	6	2/M	7	5	–	
			c	5	2/M	5	7	–	
17	Saran (Formula 113/49) over Formula 117 (8 mil)	15	a	9	1/F	9	9	10	
			b	8	2/F	8	8	4/L	
			c	8	2/M	9	8	6/L	
		16	a	9	2/F	9	9	10	
			b	8	2/F	8	8	2/M	
			c	8	2/M	8	8	8/L	
		17	a	9	2/F	9	9	10	
			b	8	2/F	8	8	4/M	
			c	8	2/F	8	8	6/L	
		18	a	9	2/F	9	9	10	18 years – Only few blisters in evidence at this time.
			b	8	2/F	8	8	5/H	
			c	8	2/F	8	8	8/M	
		19	a	9	2/F	9	9	10	
			b	8	2/F	8	8	5/L	
			c	7	2/F	8	7	8/L	
		20	a	9	2/F	9	9	10	
			b	8	2/M	8	8	/L	
			c	7	2/F	7	8	/M	
18	Saran (Formula 113/49) over flame-sprayed zinc (10 mil)	15	a	10	10	10	10	10	
			b	9	2/M	9	9	5/L	
			c	9	2/MD	9	9	8/L	
		16	a	10	10	10	10	10	
			b	9	2/MD	9	10	2/L	
			c	9	2/D	9	9	8/L	

continued

Series 2 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
18 cont'd									
		17	a	10	10	10	10	10	
			b	9	2/MD	9	10	6/L	
			c	8	2/D	9	9	8/L	
		18	a	10	10	10	10	10	
			b	9	2/MD	9	10	2/H	
			c	8	2/D	9	8	5/M	
		19	a	10	10	10	10	10	19 years – Black rust where larger blisters are broken. No pitting.
			b	9	2/D	9	10	–	
			c	7	2/D	9	7	–	
		20	a	10	10	10	10	10	20 years – Systems removed from test.
			b	8	2/M	9	8	/L	
			c	5	2/D	9	5	/H	
22	Vinyl (Formula 119) over flame-sprayed zinc (7 mil)	15	a	10	2/M	10	10	10	
			b	9	2/D	10	9	L/L	
			c	9	2/D	10	9	8/L	
		16	a	10	2/M	10	10	10	
			b	9	2/D	10	9	5/L	
			c	9	2/VD	10	9	8/L	
		17	a	10	2/MD	9+	10	10	
			b	9	2/D	9	9	4	
			c	9	2/D	9	9	8	

continued

Series 2 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
22 cont'd		18	a	10	2/MD	9	10	10	15 to 20 years – Blisters in zone a are zinc bumps.
			b	9	2/D	9	9	6/M	
			c	8	2/VD	9	8	7/L	
		19	a	10	2/MD	9	10	10	
			b	9	2/F	9	9	9	
			c	8	2/D	9	8	9	
		20	a	9	2/MD	9	10	10	
			b	9	2/F	9	9	/L	
			c	8	2/F	9	7	/L	
34	Vinyl over flame-sprayed zinc (7.5 mil)	15	a	9	2/M	9	9	10	15 years – Galvanic corrosion, pitting, and rusting.
			b	6	2/D	8	6	4/M	15 years – System removed from test.
			c	5	2/D	8	2	7/L	
36	Phenolic mastic (9 mil)	15	a	9+	10	9	10	10	
			b	9	10	9	10	5/L	
			c	9	10	9	10	8/L	
		16	a	9+	10	9+	10	10	
			b	9	10	9	10	6/L	
			c	9	10	9	10	8/L	
		17	a	9	2/F	9	10	10	
			b	9	10	9	10	2/L	
			c	9	2/F	9	10	6/L	
		18	a	9	2/F	9	10	10	
			b	9	10	9	10	4/L	
			c	9	2/F	9	9	7/L	
		19	a	9	2/F	9	10	10	15 to 20 years – Galvanic corrosion on lower end.
			b	9	10	9	10	–	
			c	9	2/F	9	9	–	
		20	a	9	2/F	9	10	10	
			b	9	10	9	10	/L	
			c	8	2/F	9	8	/L	

continued

Series 2 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
37	Phenolic mastic over Formula 117 (9 mil)	15	a	9	10	9+	10	10	
			b	9	2/F	9	9	7/L	
			c	9	2/F	9	9	9/L	
		16	a	9	10	9+	10	10	
			b	9	2/F	9	9	5/L	
			c	9	2/F	9	9	8/L	
		17	a	9	10	9	10	10	
			b	9	2/F	9	9-	4/L	
			c	8	2/F	9	8	8/L	
		18	a	9	10	9	10	10	
			b	9	2/F	9	9	5/L	
			c	8	10	9	8	7/L	
		19	a	9	10	9	10	10	19 years – Blisters broken, light pinpoint rusting.
			b	9	2/F	9	9	4/L	No new blistering in zone.
			c	8	10	9	8	8/L	
		20	a	9	10	9	10	10	20 years – Pitting still light in zone c.
			b	9	10	9	9	/L	
			c	8	10	9	8	/L	
38	Phenolic mastic with mica filler (19.5 mil)	15	a	7	10	7	7	10	
			b	9	2/VF	9	9	4/L	
			c	9	2/VF	10	9	6/L	
		16	a	7	2/F	7	7	10	
			b	9	2/F	9	9	5/L	
			c	9	2/F	10	9	8/L	
		17	a	7	2/F	7	7	10	
			b	9	2/F	9	9	5/L	
			c	9	2/F	10	9	8/L	
		18	a	7	2/F	7	7	10	
			b	9	2/F	9	9	3/L	
			c	8	2/F	10	9	7/L	

continued

Series 2 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
38 cont'd		19	a	7	2/F	7	5	10	16 to 17 years – Undercutting medium to heavy in zone a.
			b	9	–	9	9	2/L	
			c	8	–	10	9	8/L	
		20	a	5	2/F	5	–	10	17 to 19 years – Undercutting heavy in zone a.
			b	9	10	10	–	/L	20 years – System removed from test.
			c	8	10	10	–	/L	
42	Epoxy over flame-sprayed zinc (8.5 mil)	15	a	9+	2/M	10	9+	10	
			b	9	2/M	10	9	5/L	
			c	9	2/M	10	9	8/L	
		16	a	8	2/M	10	8	10	
			b	9	2/D	10	9	6/L	
			c	9	2/D	10	9	8/L	
		17	a	8	–	9	8	10	
			b	9	2/D	10	9	4/M	
			c	9	2/D	10	9	7/L	
		18	a	8	2/D	9	8	10	16 to 17 years – Very light pitting in zone c.
			b	9	2/MD	10	9	2/H	
			c	8	2/D	10	8	4/H	
		19	a	8	2/F	9	8	10	18 to 19 years – Many blisters broken permitting light rusting.
			b	9	2/F	10	9	6/L	
			c	8	2/MD	10	8	8/L	
		20	a	7	2/M	8	7	10	20 years – System removed from test.
			b	9	2/F	10	9	/L	
			c	7	2/MD	10	7	/L	
50	Furan over flame-sprayed zinc (7 mil)	15	a	7	2/M	7	7	/L	15 to 16 years – Blistering probably cause of rusting in zone b; however, this may also be result of fouling damage
			b	8	2/D	8	8	–	
			c	8	2/D	8	8	/L	
		16	a	7	2/MD	7	7	/L	16 years – System removed from test.
			b	7	2/D	7	7	–	
			c	8	2/D	8	7	/L	

continued

Series 4

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
71	Vinyl mastic (10.5 mil)	13-1/2	a	9	2/M	9	9	10	
			b	6	2/D	6	8	2/M	
			c	8	2/D	8	8	6/M	
		14-1/2	a	9	2/F	9	9	10	
			b	7	2/D	7	8	4/L	
			c	8	2/D	8	8	8/L	
		15-1/2	a	9	2/F	9	9	10	15-1/2 years – Blisters almost nonexistent. Very light undercutting in zones b, c. Severe galvanic action in zone c.
			b	7	2/F	7	8	5/L	
			c	8	2/F	8	8	8/L	
		16-1/2	a	9-	2/F	9	9	10	
			b	7	2/F	7	8	4/L	
			c	8	2/F	8	8	6/L	
		17-1/2	a	9-	2/F	8	9-	10	15-1/2 to 17-1/2 years – Very light pitting in zones b and c.
			b	6	2/F	6	8	5/L	
			c	8	2/F	8	8	8/M	
		18-1/2	a	9-	2/F	10	10	10	18-1/2 years – Removed from test.
			b	6	2/F	6	8	–	
			c	7	2/F	8	7	–	
72	Phenolic mastic (15.5 mil)	13-1/2	a	9	10	9	10	10	
			b	9	2/F	6	8	2/M	
			c	8	2/F	8	8	6/M	
		14-1/2	a	9	10	9	9	10	
			b	9	2/F	9	9	6/L	
			c	8	2/F	9	8	8/L	
		15-1/2	a	9	10	9	9	10	
			b	9	2/F	9	9	8/L	
			c	8	2/F	9	8	9/L	
		16-1/2	a	9	10	9	9	10	13-1/2 to 18-1/2 years – Edge rusting in all zones.
			b	9	2/F	9	9	4/H	
			c	8	2/F	8	8	6/H	

continued

Series 4 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
72 cont'd		17-1/2	a	9	10	8	9-	10	
			b	9	2/F	9	9-	6/L	
			c	8	2/F	8	9	8/M	
		18-1/2	a	8	10	8	9	10	
			b	9	2/F	9	9	/L	
			c	8	2/F	8	9	/L	
84	Flame-sprayed aluminum (4 mil)	13-1/2	a	10	10	10	10	10	
			b	8	10	8	10	4/M	
			c	9	10	9	10	6/M	
		14-1/2	a	9	10	9	10	10	
			b	8	10	8	10	2/L	
			c	9	10	9	10	8/L	
		15-1/2	a	9	10	9	10	10	
			b	8	10	8	10	6/L	
			c	9	10	9	10	9	
		16-1/2	a	9	10	9	10	10	12-1/2 to 18-1/2 years – Undercutting along edges. Pitting still rated light.
			b	8	10	8	10	4/L	
			c	9	10	9	10	8/L	
		17-1/2	a	9	10	9	10	10	
			b	8	10	8	10	6/L	
			c	9	10	9	10	8/M	
		18-1/2	a	9	10	9	10	10	
			b	8	10	8	10	–	
			c	9	10	9	10	–	
Series 5									
87	Coal tar-epoxy (12 mil)	13	a	8	2/F	9	8	10	
			b	9	2/F	9	9	6/L	
			c	8	2/MD	9	8	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
87 cont'd		14	a	8	2/F	8	8	10	
			b	9	2/F	9	9	4/L	
			c	8	2/MD	9	8	6/M	
		15	a	8	2/F	8	8	10	
			b	9	2/F	9	8	2/H	
			c	8	2/M	9	8	6/M	
		16	a	8	2/F	8	8	10	16 years – Pinpoint rusting in zone c.
			b	9	2/F	9	9	4/M	
			c	8	2/M	9	8	8/M	
		17	a	7	2/MD	7	7	10	
			b	9	2/F	8	9	/M	
			c	8	–	8	9	/M	
95	Vinyl (5.5 mil)	12-1/2	a	9	2/F	9	9	10	
			b	8	2/MD	8	8	4/L	
			c	7	2/MD	7	8	8/L	
		13-1/2	a	9	2/F	8	8	10	
			b	8	2/F	8	8	2/L	
			c	7	2/F	7	8	8/L	
		14-1/2	a	9	2/F	8	8	10	14-1/2 to 16-1/2 years – Backside of this panel is in poor condition.
			b	8	2/F	8	8	4/L	
			c	7	2/F	7	8	8/L	
		15-1/2	a	8	2/F	8	8	10	
			b	8	2/F	8	8	4/H	
			c	7	2/F	7	8	6/M	
		16-1/2	a	8	2/M	8	8	10	16-1/2 years – Light undercutting in zone a.
			b	8	2/F	8	8	6/L	
			c	7	2/F	7	8	8/L	
									17-1/2 Years – Panel lost.

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
97	Epoxy (9 mil)	12	a	7	10	9	7	10	
			b	9	2/MD	9	9	2/M	
			c	9	2/D	9	9	6/M	
		13	a	7	2/F	9	7	10	
			b	8	2/F	8	9	6/L	
			c	8	2/D	8	9	8/L	
		14	a	7	2/M	8	7	10	
			b	8	2/F	8	9	5/L	
			c	8	2/F	8	9	8/L	
		15	a	7	–	7	7	10	
			b	8	2/F	8	8	5/L	
			c	8	2/F	8	9	5/L	
		16	a	5	2/F	5	5	10	14 to 16 years – Undercutting in zone a becoming progressively more severe.
			b	8	2/F	8	8	2/H	16 years – System removed from test.
			c	8	2/F	8	8	6/M	
99	Chlorosulfonated polyethylene (8.5 mil)	11	a	8	–	8	–	10	
			b	6	2/D	7	6	4/L	
			c	8	2/D	8	8	8/L	
		12	a	8	10	8	8	10	
			b	6	2/MD	7	6	6/L	
			c	8	2/D	8	8	7/M	
		13	a	8	2/F	8	8	10	
			b	6	2/MD	7	6	5/L	
			c	8	2/D	8	8	8/L	
		14	a	8	2/F	8	8	10	
			b	6	2/D	7	6	4/M	
			c	8	2/D	8	8	6/L	
		15	a	8	2/F	8	8	10	15 to 16 years – Coating losing adhesion to substrate, permitting rusting – more severe in zone a than in zones b and c. Primer tends to solubilize in zones b and c.
			b	6	2/D	7	6	6/M	
			c	8	2/D	8	8	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
99 cont'd		16	a	8	2/F	8	9	10	
			b	6	2/F	6	8	/L	
			c	8	2/F	8	8	/L	
100	Zinc-filled modified epoxy (6 mil)	11	a	9	2/F	9	10	10	Since blisters could not be differentiated from zinc pigment nodules or salts, both were rated as blisters.
			b	8	2/D	9	9	6/M	
			c	7	2/D	8	8	8/L	
		12	a	9	2/F	9	10	10	
			b	8	2/D	9	8	4/L	
			c	7	2/D	8	8	6/L	
		13	a	9	2/F	9	10	10	13 to 16 years – Pinpoint rusting.
			b	8	2/D	9	8	5/L	
			c	7	2/D	8	8	8/L	
		14	a	9	2/F	9	10	10	
			b	8	2/D	9	8	3/H	
			c	7	2/D	8	7	6/M	
		15	a	9	2/M	9	10	10	
			b	8	2/D	9	9	5/L	
			c	7	2/D	8	7	9/L	
		16	a	9	8/D	9	10	10	
			b	8	8/D	8	9	/H	
			c	7	8/D	9	7	/L	
101	Epoxy (12 mil)	11	a	9	10	9	10	10	11 to 16 years – Checking:
			b	9	2/F	9	10	2/H	zone a – 8
			c	8	2/F	8	10	6/M	zone b – 2
									zone c – 8
		12	a	9	10	9	10	10	
			b	9	2/F	9	9	4/L	
			c	8	2/F	8	9	8/L	
		13	a	9	2/F	9	10	10	
			b	9	2/F	9	9	4/LM	
			c	8	2/F	8	9	7/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting		Fouling[b] Attachment	Remarks
						1	2		
101 cont'd		14	a	9	–	9	10	10	
			b	9	–	9	9	2/H	
			c	8	–	8	8	6/H	
		15	a	9	2/F	9	9	10	15 to 16 years – Barnacles have removed topcoat from primer.
			b	9	10	9	9	4/L	
			c	8	2/F	8	8	8/L	
		16	a	9	2/F	9	9	10	
			b	9	10	9	9	/L	
			c	8	2/M	8	8	/M	
102	Aluminum-pigmented urethane (5.5 mil)	11	a	10	10	10	10	10	
			b	9	2/F	9	9	4/M	
			c	9	2/MD	9	8	8/L	
		12	a	10	10	10	10	10	
			b	9	2/F	9	9	5/L	
			c	9	2/MD	9	8	6/L	
		13	a	10	10	10	10	10	
			b	9	2/F	9	9	4/M	
			c	8	2/MD	9	8	6/M	
		14	a	10	10	10	10	10	14 to 16 years – Most blisters have broken, primer is protecting steel. Most of topcoat removed in zones b and c.
			b	9	2/F	9	9	6/L	
			c	8	2/F	9	8	9/L	
		15	a	10	10	10	10	10	
			b	9	2/F	9	9	5/L	
			c	7	2/F	8	7	7/M	
		16	a	10	10	10	10	10	
			b	9	2/M	9	9	/M	
			c	7	2/M	8	7	/H	
103	Aluminum-pigmented coal tar-epoxy (24.5 mil)	11	a	10	10	10	10	10	17 years – System slightly damaged at top of panel.
			b	10	8/F	10	10	4/H	
			c	10	8/F	10	10	6/H	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
103 cont'd		12	a	10	10	10	10	10	
			b	10	8/F	10	10	5/M	
			c	10	8/F	10	10	7/M	
		13	a	10	10	10	10	10	
			b	10	6/F	10	10	4/M	
			c	10	6/F	10	10	8/M	
		14	a	10	10	10	10	10	
			b	10	4/F	10	10	2/M	
			c	10	4/F	10	10	6/M	
		15	a	10	10	10	10	10	
			b	10	2/F	10	10	4/L	
			c	10	2/F	10	10	6/M	
		16	a	10	10	10	10	10	
			b	10	2/F	10	10	–	
			c	10	2/F	10	10	–	
106	Aluminum-pigmented vinyl (6.5 mil)	11	a	9	10	9	10	10	
			b	8	2/F	8	9	4/M	
			c	9	2/F	9	9	8/L	
		12	a	9	10	9	10	10	
			b	8	2/F	8	9	5/L	
			c	9	2/F	9	9	8/L	
		13	a	8	10	8	9	10	13 to 16 years – Light pitting and galvanic corrosion, bottom of zone c.
			b	8	2/F	8	9	2/L	
			c	9	2/F	9	9	6/M	
		14	a	8	10	9	9	10	
			b	8	2/F	8	8	2/H	
			c	9	2/F	9	9	8/M	
		15	a	8	2/F	9	9	10	
			b	8	8/D	8	8	4/L	
			c	9	8/D	9	9	6/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
106 cont'd		16	a	8	2/F	9	9	10	
			b	8	8/M	8	8	/L	
			c	9	8/M	9	8	/L	
108	Coal tar-epoxy (8 mil)	10-1/2	a	9	10	9	10	10	
			b	9	2/F	9	10	2/M	
			c	9	10	9	10	6/M	
		11-1/2	a	9	10	9	10	10	
			b	9	2/F	9	10	4/L	
			c	9	10	9	10	8/L	
		12-1/2	a	8	10	8	10	10	
			b	9	10	9	10	2/L	
			c	9	10	9	10	6/M	
		13-1/2	a	8	10	8	10	10	
			b	9	10	9	10	4/M	
			c	9	10	8	10	6/M	
		14-1/2	a	8	10	8	10	10	11-1/2 to 14-1/2 years – Light undercutting at edges; light peeling in zones a, b; pinpoint rusting.
			b	9	10	9	10	2/M	
			c	9	10	9	10	6/M	
		15-1/2	a	7	10	7	10	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
109	Epoxy (7 mil)	10-1/2	a	8	2/D	9	8	10	
			b	9	10	9	10	4/L	
			c	10	10	10	10	8/L	
		11-1/2	a	8	2/D	9	8	10	
			b	9	10	9	10	2/L	
			c	10	10	10	10	8/L	
		12-1/2	a	8	2/D	9	8	10	
			b	9	10	9	10	4/L	
			c	10	10	10	10	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting		Fouling[b] Attachment	Remarks
						1	2		
109 cont'd		13-1/2	a	8	2/D	8	8	10	
			b	9	10	9	10	2/H	
			c	10	10	10	10	5/H	
		14-1/2	a	7	2/F	7	7	10	11-1/2 to 14-1/2 years – Light to medium undercutting along edges.
			b	9	2/F	9	10	4/M	
			c	9	10	9+	10	8/M	
		15-1/2	a	5	–	6	5	10	14-1/2 to 15-1/2 years – Zone a very bad condition.
			b	9	2/F	10	9	/L	15-1/2 years – System removed from test.
			c	9	10	10	8	/H	
110	Tetrafluoro-ethylene over epoxy (8 mil)	10-1/2	a	9	10	9	10	10	
			b	9	10	9	10	3/M	
			c	9	10	9	10	8/L	
		11-1/2	a	9	2/F	9	9	10	
			b	9	2/M	9	10	5/L	
			c	9	2/F	9	10	8/L	
		12-1/2	a	9	2/F	9	10	10	
			b	9	2/F	9	10	2/L	
			c	9	2/F	9	10	6/L	
		13-1/2	a	9	2/F	9	9	10	
			b	9	2/F	9	10	2/H	
			c	9	2/F	9	10	4/H	
		14-1/2	a	9	2/F	9	8	10	
			b	9	2/F	9	10	3/H	
			c	9	2/F	9	10	5/H	
		15-1/2	a	8	2/F	8	8	10	
			b	9	2/F	9	10	/H	
			c	9	2/F	9	10	/L	
112	Urethane (7.5 mil)	9-1/2	a	9	10	9	10	10	
			b	9	10	9	10	2/H	
			c	9	10	9	10	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
112 cont'd		10-1/2	a	9	10	9	10	10	
			b	9	10	9	10	3/L	
			c	9	10	9	10	7/M	
		11-1/2	a	9	10	9	10	10	10-1/2 to 14-1/2 years – Topcoat removed in several areas of zones b and c, partially due to barnacles. Primer provides some protection, but galvanic corrosion and light pitting observed in zone b.
			b	9	10	9	10	5/L	
			c	9	10	9	10	8/M	
		12-1/2	a	9	10	9	9	10	
			b	8	10	8	10	6/L	
			c	9	10	9	10	7/M	
		13-1/2	a	9	10	9	9	10	
			b	8	10	8	10	10	
			c	9	10	9	10	10	
		14-1/2	a	9	10	9	9	10	
			b	8	10	8	10	/H	
			c	8	10	9	10	/H	
114	Coal tar-urethane (9.5 mil)	9-1/2	a	8	10	9	10	10	9-1/2 to 14-1/2 years – Light fouling damage.
			b	8	2/MD	9	8	2/H	
			c	9	2/F	9+	9	5/M	
		10-1/2	a	8	2/MD	9	8	10	
			b	8	2/M	9	8	4/L	
			c	9	2/F	9	9	8/L	
		11-1/2	a	7	2/MD	8	7	10	
			b	8	2/M	9	8	4/H	
			c	9	2/F	9	9	6/H	
		12-1/2	a	7	2/D	8	7	10	
			b	8	2/M	9	8	2/H	
			c	9	2/F	9	9	6/H	
		13-1/2	a	7	2/F	8	7	10	
			b	8	2/F	9	8	3/H	
			c	9	2/F	9	9	7/H	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
114 cont'd		14-1/2	a	5	2/F	6	5	10	14-1/2 years – Removed from test.
			b	7	2/F	8	8	/H	
			c	9	2/F	9	9	/H	
115	Vinyl (11 mil)	8-1/2	a	10	10	10	10	10	
			b	9	2/F	9	10	2/L	
			c	9	10	9	10	6/L	
		9-1/2	a	10	10	10	10	10	
			b	9	2/F	9	9	4/M	
			c	9	10	9	10	8/L	
		10-1/2	a	10	10	10	10	10	
			b	9	2/F	9	9	2/L	
			c	9	10	9	10	4/L	
		11-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	4/M	
			c	9	10	9	9	8/L	
		12-1/2	a	9	10	9	10	10	12-1/2 to 14-1/2 years – Light pinpoint rusting in zones b and c.
			b	8	2/F	9	9	2/H	
			c	9	10	9	9	6/M	
		13-1/2	a	9	10	9	10	10	
			b	8	2/F	9	8	3/M	
			c	9	10	9	8	8/M	
		14-1/2	a	9	10	9	10	10	
			b	8	10	8	8	/M	
			c	9	10	9	8	/H	
116	Epoxy (9.5 mil)	9-1/2	a	9	10	9	10	10	9-1/2 to 13-1/2 years – Most of rusting occurred along the edges.
			b	9	2/F	9	9	3/L	
			c	9	10	9	10	8/L	
		10-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	2/L	
			c	9	10	9	10	6/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
116 cont'd		11-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	4/L	
			c	9	10	9	10	8/L	
		12-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	5/L	
			c	9	2/F	9	9	9/L	
		13-1/2	a	9	10	9	10	10	13-1/2 to 14-1/2 years – Light pinpoint rusting in zone c.
			b	9	2/F	9	9	4/L	
			c	9	2/F	9	9	6/L	
		14-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	/M	
			c	8	10	9	8	/M	
117	Coal tar-epoxy (16.5 mil)	9-1/2	a	10	10	10	10	10	
			b	9	10	9	10	2/M	
			c	10	10	10	10	6/L	
		10-1/2	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	10	10	10	10	8/L	
		11-1/2	a	10	2/F	10	10	10	
			b	9	10	9	10	6/L	
			c	10	10	10	10	8/L	
		12-1/2	a	10	2/F	10	10	10	12-1/2 years – Galvanic corrosion on end of panel.
			b	9	2/F	9	10	3/L	
			c	10	10	10	10	8/L	
		13-1/2	a	9	2/F	9	10	10	
			b	9	2/F	9	10	5/L	
			c	9	10	9	9	7/L	
		14-1/2	a	9	2/F	9	9	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
118	Coal tar-epoxy (17.5 mil)	8-1/2	a	10	10	10	10	–	
			b	9	10	9	10	–	
			c	10	10	10	10	–	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
118 cont'd		9-1/2	a	10	10	10	10	10	
			b	9	10	9	10	3/L	
			c	10	10	10	10	8/L	
		10-1/2	a	10	10	10	10	10	
			b	9	2/F	9	10	2/H	
			c	10	2/F	10	10	5/L	
		11-1/2	a	10	10	10	10	10	
			b	9	2/F	9	10	3/H	
			c	10	10	10	10	7/M	
		12-1/2	a	10	2/F	10	10	10	
			b	9	10	9	10	2/M	
			c	10	10	10	10	6/M	
		13-1/2	a	9	2/F	9	10	/L	
			b	9	10	9	10	/H	
			c	10	10	10	10	–	
120	Modified phenolic (12 mil)	8-1/2	a	8	10	8	10	10	
			b	9	2/F	9	9	2/M	
			c	8	2/F	9	8	6/M	
		9-1/2	a	8	2/F	9	8	10	
			b	9	2/F	9	9	4/L	
			c	8	2/F	9	8	8/L	
		10-1/2	a	8	2/F	8	8	10	
			b	9	2/F	9	9	2/M	
			c	8	2/F	9	8	8/L	
		11-1/2	a	7	2/F	7	7	10	
			b	9	2/F	9	9	2/H	
			c	8	2/F	9	8	6/H	
		12-1/2	a	7	2/M	7	7	10	
			b	9	2/F	9	9	5/L	
			c	8	2/F	9	8	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
120 cont'd		13-1/2	a	5	–	5	5	10	11-1/2 to 13-1/2 years – Galvanic corrosion in zone c.
			b	9	2/F	9	9	/M	13-1/2 years – System removed from test.
			c	6	2/M	9	6	/M	
122	Urethane (7.5 mil)	7-1/2	a	9	10	9	10	10	
			b	8	2/D	8	9	6/M	
			c	8	2/D	8	9	8/L	
		8-1/2	a	9	10	9	10	10	
			b	8	2/D	8	8	4/L	
			c	8	2/D	8	9	7/L	
		9-1/2	a	9	2/F	9	10	10	
			b	8	2/D	8	8	2/L	
			c	8	2/D	8	9	8/L	
		10-1/2	a	9	2/F	9	10	10	10-1/2 to 13-1/2 years – Blisters rigid, filled with black rust.
			b	8	2/D	8	8	4/L	
			c	8	2/D	8	9	6/L	
		11-1/2	a	9	2/F	9	10	10	
			b	8	2/D	8	8	3/L	
			c	8	2/D	8	8	9/L	
		12-1/2	a	8	2/F	8	8	10	12-1/2 to 13-1/2 years – Light pinpoint rusting.
			b	8	2/F	8	9	2/M	
			c	8	2/F	8	9	4/M	
		13-1/2	a	7	2/F	7	8	10	
			b	8	–	8	9	4/M	
			c	8	2/M	8	9	1/H	
123	Epoxy phenolic (14 mil)	7-1/2	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	9/L	
		8-1/2	a	10	10	10	10	10	
			b	10	2/M	10	10	2/L	
			c	10	2/M	10	10	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
123 cont'd		9-1/2	a	10	10	10	10	10	
			b	10	2/M	10	10	4/L	
			c	10	2/M	10	10	8/L	
		10-1/2	a	10	10	10	10	10	
			b	10	2/F	10	10	2/H	
			c	10	2/M	10	10	6/H	
		11-1/2	a	10	10	10	10	10	11-1/2 to 12-1/2 years – Few pinpoint rust spots.
			b	9+	2/F	9+	10	2/L	
			c	9+	2/F	9+	10	7/M	
		12-1/2	a	10	10	10	10	10	
			b	9	2/F	9	10	/H	
			c	9	2/F	9	10	/H	
124	Epoxy (14 mil)	7-1/2	a	9	10	9	10	10	
			b	9	2/F	9	9	6/L	
			c	9	2/F	9	10	8/L	
		8-1/2	a	8	2/F	9	8	10	
			b	9	2/MD	9	9	4/L	
			c	9	2/MD	9	10	6/L	
		9-1/2	a	8	2/F	9	8	10	
			b	9	2/M	9	9	2/L	
			c	9	2/M	9	9	8/L	
		10-1/2	a	8	2/F	8	8	10	10-1/2 to 12-1/2 years – Galvanic corrosion bottom of zone c. Undercutting by rust; heavy in zone a.
			b	9	2/M	9	9	5/L	
			c	9	2/D	9	9	9/L	
		11-1/2	a	7	2/M	8	7	10	
			b	9	2/F	9	9	–	
			c	9	2/F	9	9	–	
		12-1/2	a	5	2/M	8	5	10	12-1/2 years – System removed from test.
			b	8	2/MD	9	8	/L	
			c	9	2/F	9	9	/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
126	Vinyl (12 mil)	6-1/2	a	10	10	10	10	10	6-1/2 years – Loss of adhesion: light in zone b.
			b	9	2/M	9	9	2/M	
			c	8	2/M	9	8	6/L	
		7-1/2	a	10	10	10	10	10	
			b	9	2/M	9	9	4/M	
			c	8	2/M	9	8	8/L	
		8-1/2	a	9	2/F	9	9	10	
			b	9	2/F	9	9	2/L	
			c	8	2/F	9	8	8/L	
		9-1/2	a	9	2/F	9	9	10	
			b	9	2/F	9	9	5/L	
			c	8	2/F	9	8	6/L	
		10-1/2	a	9	2/F	9	9	10	10-1/2 to 12-1/2 years – Adhesion loss: light in zone c. Pitting: light in zone c. Galvanic corrosion: light in zone c.
			b	9	2/F	9	9	2/L	
			c	8	2/F	9	8	8/L	
		11-1/2	a	9	2/F	9	9	10	
			b	8	2/F	9	9	–	
			c	8	2/F	9	8	–	
		12-1/2	a	9	2/F	9	9	10	
			b	8	2/F	9	8	/L	
			c	8	2/F	9	8	/L	
127	Urethane (10 mil)	6-1/2	a	9 +	10	9	9	10	
			b	9	2/D	10	8	2/M	
			c	8	2/D	10	8	8/L	
		7-1/2	a	9	10	9	9	10	
			b	9	2/D	10	8	2/M	
			c	8	2/D	10	8	6/M	
		8-1/2	a	9	2/F	9	10	10	
			b	9	2/D	10	9	2/L	
			c	8	2/D	10	8	8/L	

continued

Series 5 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
127 cont'd		9-1/2	a	9+	2/F	9	10	10	
			b	9	2/D	10	9	/L	
			c	8	2/D	10	8	8/L	
		10-1/2	a	9+	2/F	9	10	10	
			b	9	10	9	9	0/L	
			c	8	8/M	10	7	9	
		11-1/2	a	9	2/F	9	10	10	9-1/2 to 11-1/2 years – Most of topcoat removed in zone b. Primer protecting metal.
			b	9	10	9	9	9	
			c	7	8/D	10	7	7	
Series 6									
128	Coal tar-epoxy over zinc inorganic silicate (11.5 mil)	5	a	10-	2/F	9+	10	10	
			b	9+	2/M	9	9+	4/M	
			c	9+	2/M	9	9+	8/L	
		6	a	10-	2/F	9+	10	10	
			b	9	2/M	9	9	4/L	
			c	9	2/M	9	9	8/L	
		7	a	10-	2/F	9+	10	10	
			b	9	2/F	9	9	2/M	
			c	9	2/M	9	9	6/L	
		8	a	9	2/F	9	9	10	
			b	9	2/F	9	8	2/H	
			c	9	2/M	9	8	5/M	
		9	a	9	2/F	9	9	10	
			b	8	2/F	9	8	4/L	
			c	8	2/M	9	8	8/L	
		10	a	9	2/F	9	9	10	
			b	8	2/F	9	8	/L	
			c	8	2/F	9	8	/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
128 cont'd		11	a	9	10	9	9	10	
			b	8	2/F	9	8	/L	
			c	8	2/F	9	8	/L	
129	Vinyl over zinc inorganic silicate (14 mil)	5	a	10	10	10	10	10	5 years – Very slight erosion of topcoat, exposing primer.
			b	10	10	10	10	4/M	
			c	10	2/F	10	10	8/L	
		6	a	10	10	10	10	10	6 years – Blisters have ruptured but no rusting to date.
			b	10	10	10	10	5/L	
			c	10	2/MD	10	10	9/L	
		7	a	9+	10	9+	10	10	
			b	10	2/F	10	10	4/L	
			c	10	2/F	10	10	8/L	
		8	a	9	10	9	10	10	
			b	10	2/F	10	10	2/H	
			c	9	2/F	9	10	6/H	
		9	a	9	10	9	10	10	
			b	10	2/F	10	10	3/L	
			c	8	2/F	8	10	7/M	
		10	a	9	10	9	10	–	10 years – Light galvanic corrosion in zone c.
			b	10	2/F	10	10	–	
			c	8	10	8	10	–	
		11	a	9	10	9	10	–	
			b	10	2/F	10	10	–	
			c	8	10	8	10	–	
130	Epoxy over zinc inorganic silicate (11 mil)	5	a	10	10	10	10	10	
			b	10	10	10	10	3/M	
			c	10	2/F	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	2/MD	10	10	8/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
130 cont'd		7	a	10	10	10	10	10	7 years – Barnacles starting to remove topcoat.
			b	9+	10	9+	10	4/M	
			c	10	2/F	10	10	9/L	
		8	a	10	10	10	10	10	
			b	9+	10	9+	10	5/L	
			c	10	2/F	10	10	8/L	
		9	a	10	10	10	10	10	
			b	9+	10	9+	10	5/L	
			c	10	2/F	10	10	7/L	
		10	a	9	10	9	10	10	
			b	9+	2/F	9+	10	/L	
			c	10	2/F	10	10	/L	
		11	a	9	10	9	10	10	
			b	9+	10	9+	10	/H	
			c	9+	10	9+	10	/L	
131	Vinyl over zinc *inorganic* silicate (14 mil)	5	a	10	10	10	10	10	
			b	10	10	10	10	6/L	
			c	10	2/VF	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	2/VF	10	10	9/L	
		7	a	9+	10	9+	10	10	7 years – Light barnacle damage in zones b and c. Topcoat removed from primer.
			b	10	2/F	10	10	2/L	
			c	10	2/F	10	10	8/L	
		8	a	9	10	9	10	10	
			b	10	10	10	10	4/L	
			c	10	2/F	10	10	9/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	4/VL	
			c	9	2/VF	9	10	8/VL	
		10	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	8	10	8	10	/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
131 cont'd		11	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	8	10	8	10	/L	
132	Epoxy over zinc inorganic silicate (12.5 mil)	5	a	10-	10	9	10	10	5 to 9 years – Heavy undercutting along edge.
			b	8	2/F	8	9	6/L	
			c	7	2/F	7	9	8/L	
		6	a	10	10	9	10	10	
			b	8	2/F	8	9	4/L	
			c	7	2/F	7	8	7/L	
		7	a	9	10	9	9	10	
			b	8	2/F	8	9	2/L	
			c	7	2/F	7	8	8/L	
		8	a	9	10	9	9	10	
			b	8	2/F	8	9	6/L	
			c	7	2/F	7	8	8/L	
		9	a	9	10	9	9	10	
			b	8	2/F	8	9	4/L	
			c	7	2/F	7	8	7/L	
		10	a	9	10	9	9	10	10 years – All blisters in zones b and c have ruptured resulting in deep pitting.
			b	8	10	8	8	/M	
			c	7	10	7	8	/L	
		11	a	9	10	9	9	10	11 years – System removed from test.
			b	7	10	7	8	/L	
			c	7	10	7	8	/L	
133	Vinyl over zinc inorganic silicate (15 mil)	5	a	10	10	10	10	10	5 to 10 years – Moderate to heavy edge rusting in all three zones. Light galvanic corrosion in zone c.
			b	9	10	9	10	4/L	
			c	9	2/F	9	10	8/L	
		6	a	9	10	9	10	10	
			b	9	10	9	10	5/L	
			c	9	2/F	9	10	8/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
133 cont'd		7	a	9	10	9	10	10	
			b	9	10	9	10	2/VL	
			c	9	2/F	9	10	8/VL	
		8	a	9	10	9	10	10	
			b	8	10	8	10	2/VL	
			c	9	2/F	9	10	8/VL	
		9	a	9	10	9	10	10	
			b	8	10	8	10	4/L	
			c	9	2/F	9	10	6/L	
		10	a	9	10	9	10	10	10 years – Heavy pitting in zone c.
			b	8	10	8	10	/L	10 years – System removed from test.
			c	6	10	6	10	/L	
134	Vinyl over zinc inorganic silicate (10 mil)	5	a	10	10	10	10	10	5 years – Primer exposed in zone c.
			b	9	2/MD	9	10	2/M	Galvanic corrosion light in zone c.
			c	9	2/MD	9	10	6/L	
		6	a	9	10	9	10	10	6 years – Pitting in zones b and c.
			b	9	10	9	10	4/L	
			c	8	2/MD	9	8	8/L	
		7	a	9	10	9	10	10	7 years – All blisters ruptured, exposing primer.
			b	9	10	9	10	2/L	
			c	8	10	9	8	7/L	
		8	a	9	10	9	10	10	
			b	9	10	9	10	1/L	
			c	8	10	9	8	8/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	8	10	9	8	8/L	
		10	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	8	10	9	8	/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
134 cont'd		11	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	8	10	9	8	/L	
135	Vinyl over zinc inorganic silicate (15 mil)	5	a	10	10	10	10	10	
			b	9	2/M	9	10	5/L	
			c	9	2/M	9	10	8/L	
		6	a	9	10	9	10	10	
			b	9	2/M	9	10	4/L	
			c	9	2/M	9	10	6/L	
		7	a	9	10	9	9	10	7 years – Blisters have ruptured in zone b, resulting in light rusting.
			b	9	10	9	9	2/L	
			c	9	10	9	9	8/L	
		8	a	9	10	9	9	10	8 to 9 years – Light pitting zone c.
			b	9	10	9	9	5/L	
			c	9	2/F	9	9	9/L	
		9	a	9	10	9	9	10	
			b	9	10	9	9	2/L	
			c	9	2/F	9	8	8/L	
		10	a	9	10	9	9	10	
			b	8	10	8	9	/L	
			c	8	10	8	8	/L	
		11	a	9	10	8	9	10	11 years – Galvanic corrosion along edges of zone c.
			b	8	10	8	9	/L	
			c	7	10	7	8	/L	
136	Epoxy over zinc inorganic silicate (14 mil)	5	a	10	10	10	10	10	
			b	9	10	9	10	5/L	
			c	9	2/F	9	10	8/L	
		6	a	9	10	9	10	10	
			b	9	10	9	10	2/L	
			c	9	2/F	9	10	8/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
136 cont'd		7	a	9	2/F	9	9	10	7 to 9 years – Very light pitting in zone a.
			b	9	2/VF	9	10	4/L	
			c	9	2/VF	9	10	7/L	
		8	a	8	2/F	9	8	10	
			b	9	10	9	10	2/L	
			c	9	10	9	10	6/L	
		9	a	8	2/F	8	8	10	
			b	9	10	9	9	4/L	
			c	9	10	9	9	8/L	
		10	a	7	2/F	7	7	10	10 years – Heavy pitting in zone a, light galvanic corrosion in zone c.
			b	9	10	9	9	/L	
			c	8	10	9	8	/L	
		11	a	5	2/M	8	5	10	11 years – Heavy undercutting by rust in zone a. System removed from test.
			b	9	2/F	9	9	/M	
			c	8	2/F	9	8	/L	
138	Epoxy over zinc inorganic silicate (15 mil)	5	a	10	10	10	10	10	5 to 10 years – Light flaking of coating system from primer in zones b and c.
			b	9	2/F	9	10	4/L	
			c	8	2/F	8	10	7/L	
		6	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	8	2/F	8	10	8/L	
		7	a	10	10	10	10	10	7 years – Pitting in zone c.
			b	9	10	9	10	2/L	
			c	8	2/F	8	9	5/L	
		8	a	10	10	10	10	10	
			b	9	10	9	10	3/M	
			c	8	2/F	8	9	5/L	
		9	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	8	2/F	8	9	8/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
138 cont'd		10	a	10	10	10	10	10	10 years – Light fouling damage in zone c.
			b	9	10	9	8	/L	
			c	8	10	8	8	/L	
		11	a	10	10	10	10	10	11 years – Flaking of topcoat at edges. Pitting resulting from fouling damage. Galvanic corrosion in zone c.
			b	9	10	9	8	/M	
			c	7	10	8	7	/L	
139	Vinyl over zinc inorganic silicate (14.5 mil)	5	a	9	10	9	10	10	5 to 6 years – Light galvanic corrosion in zone c.
			b	9	10	9	10	5/L	
			c	9	2/F	9	10	9/L	
		6	a	9	10	9	10	10	
			b	9	10	9	10	2/L	
			c	9	2/MD	9	10	8/L	
		7	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	9	2/MD	9	10	6/L	
		8	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	8	2/F	8	10	7/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	2/L	
			c	8	2/F	8	10	8/L	
		10	a	9	10	9	10	10	
			b	9	10	9	9	/L	
			c	8	2/F	8	10	/L	
		11	a	8	10	8	10	10	11 years – Pinpoint rusting in zone c.
			b	8	10	8	9	/L	
			c	8	2/F	8	10	/L	
140	Aluminum hydrocarbon resin over zinc inorganic silicate (13 mil)	5	a	10	10	10	10	–	5 to 6 years – Galvanic corrosion in zone c along edges. Topcoat removed in zones b and c, primer and zinc inorganic silicate, providing good protection.
			b	9	2/F	9	10	–	
			c	9	2/M	9	10	–	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
140 cont'd		6	a	10	10	10	10	–	
			b	9	2/F	9	10	–	
			c	9	2/F	9	10	–	
		7	a	10	10	10	10	–	
			b	9	2/F	9	10	–	
			c	8	2/F	9	9-	–	
		8	a	9+	10	9	10	–	
			b	9	10	9	10	–	
			c	8	10	8	8	–	
		9	a	9+	10	9	10	–	
			b	8	10	8	10	–	
			c	7	10	7	7	–	
		10	a	9	10	9	10	–	10 years – Heavy pinpoint rusting in zone a. System removed from test.
			b	8	10	8	9	–	
			c	5	10	5	6	–	
141	Vinyl over zinc inorganic silicate (14 mil)	5	a	10	10	10	10	10	5 to 6 years – Topcoat peeling from silicate primer in zones b and c.
			b	8	2/MD	8	10	9/L	
			c	8	2/MD	8	10	6/L	
		6	a	10	10	10	10	10	
			b	8	2/D	8	10	4/L	
			c	8	2/D	8	10	8/L	
		7	a	10	10	10	10	10	
			b	8	2/F	8	10	2/L	
			c	8	2/F	8	10	7/L	
		8	a	10	10	10	10	10	
			b	8	2/F	8	10	3/M	
			c	8	2/F	8	10	7/L	
		9	a	10	10	10	10	10	
			b	8	2/F	8	10	2/M	
			c	7	2/F	7	10	6/M	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
141 cont'd		10	a	10	10	10	10	10	10 to 11 years – Flaking along edges has exposed zinc primer in zones b and c. Heavy rusting and pitting in zone c.
			b	8	10	8	10	/L	
			c	7	10	7	10	/L	
			a	10-	10	9+	10	10	
		11	b	8	10	8	10	/L	
			c	6	10	6	10	/L	
142	Aluminum hydrocarbon resin over zinc inorganic silicate (11 mil)	5	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	8/L	
		6	a	10	10	10	10	10	6 to 9 years – Rusting in zones b and c became progressively heavier. Galvanic corrosion along edges. Heavy pinpoint rusting in zone c.
			b	9	10	9	10	2/L	
			c	9	10	9	10	5/L	
		7	a	10	10	10	10	10	
			b	8	10	8	10	4/L	
			c	8	10	8	10	8/L	
		8	a	10	10	10	10	10	
			b	8	10	8	10	3/L	
			c	8	10	8	10	5/L	
		9	a	10	10	10	10	10	9 years – System removed from test.
			b	7	10	7	10	4/M	
			c	7	10	7	10	6/L	
143	Vinyl over zinc inorganic silicate (15 mil)	5	a	9	10	9	10	10	
			b	9	10	9	10	5/L	
			c	9	10	9	10	8/L	
		6	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			b	9	10	9	10	6/L	
		7	a	9	10	9	10	10	7 years – Some primer showing on edges.
			b	9	10	9	10	2/VL	
			c	9	10	9	10	8/VL	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
143 cont'd		8	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	6/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	3/L	
			c	9	10	9	10	7/L	
		10	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
		11	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
144	**Vinyl (10.5 mil)**	5	a	9	10	9	10	10	5 to 8 years – System shows serious loss of adhesion particularly in zone b. This is due in part to fouling damage.
			b	9	2/F	9	10	5/L	
			c	9	2/F	9	10	8/L	
		6	a	9	2/F	9	10	10	
			b	9	2/F	9	10	3/L	
			c	9	2/F	9	10	7/L	
		7	a	9	10	9	10	10	
			b	9	2/F	9	10	2/VL	
			c	8	2/F	9	10	8/VL	
		8	a	8	10	8	10	10	8 years – System removed from test.
			b	7	2/F	7	10	4/L	
			c	7	2/F	8	10	6/L	
145a	**Fiberglass-filled polyester (85 mil)**	4	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	4/M	
		5	a	10	10	10	10	10	
			b	10	10	10	10	3/L	
			c	10	10	10	10	6/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
145a cont'd		6	a	10	10	10	10	10	
			b	10	10	10	10	5/M	
			c	10	10	10	10	9/L	
		7	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	2/M	
		8	a	10	10	10	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	
		9	a	10	10	10	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/H	
Series 7									
145	Fiberglass-filled polyester (150 mil)	4	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	6/M	
		5	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	
		7	a	10	10	10	10	10	
			b	10	10	10	10	3/L	
			c	10	10	10	10	9/L	
		8	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	5/H	

continued

Series 7 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
145 cont'd		9	a	10	10	10	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/H	
146	Flakeglass-filled polyester (50 mil)	4	a	10	10	10	10	10	
			b	10	10	10	10	2/M	
			c	10	10	10	10	8/M	
		5	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/L	
		6	a	10	10	10	10	10	6 to 9 years – Rusting in zone c is in mechanically damaged area.
			b	10-	10	10-	10	2/L	
			c	10	10	10	10	8/L	
		7	a	10	10	10	10	10	
			b	10-	10	10-	10	2/H	
			c	10	10	10	10	8/L	
		8	a	10	10	10	10	10	
			b	9+	10	9+	10	5/L	
			c	10	10	10	10	8/L	
		9	a	10	10	10	10	10	
			b	9	10	9	10	/L	
			c	10	10	10	10	/L	
146a	Flakeglass-filled polyester (50 mil)	4	a	10	10	10	10	10	
			b	10	10	10	10	2/M	
			c	10	10	10	10	8/M	
		5	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	6/L	

continued

Series 6 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
146a cont'd		7	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	6/L	
		8	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	7/L	
		9	a	10	10	10	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/L	
147	Flakeglass-filled polyester (45 mil)	4	a	9	10	9	10	10	4 to 9 years – Light pinpoint rusting in zones a and b. Mechanically damaged areas showing light rusting in zone a.
			b	10	10	10	10	4/L	
			c	10	10	10	10	7/L	
		5	a	9	10	9	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	
		6	a	9	10	9	10	10	
			b	10-	10	9+	10	4/M	
			c	10	10	10	10	8/L	
		7	a	9	10	9	10	10	
			b	9+	10	9+	10	2/M	
			c	10	10	10	10	7/L	
		8	a	9	10	9	10	10	
			b	9+	10	9+	10	3/L	
			c	10	10	10	10	9/L	
		9	a	9	10	9	10	10	
			b	9+	10	9+	10	1/M	
			c	10	10	10	10	5/L	
147a	Flakeglass-filled polyester (45 mil)	4	a	9	10	9	10	–	4 to 9 years – Mechanically damaged areas showing light rusting in zones a and b.
			b	9	10	9	10	–	
			c	10	10	10	10	–	

continued

Series 7 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
147a cont'd		5	a	9	10	9	10	–	
			b	9	10	9	10	–	
			c	10	10	10	10	–	
		6	a	9	10	9	10	–	
			b	9	10	10	10	–	
			c	10	10	10	10	–	
		7	a	9	10	9	10	–	
			b	9	10	10	10	–	
			c	10	10	10	10	–	
		8	a	9	10	9	10	–	
			b	9	10	9	10	–	
			c	10	10	10	10	–	
		9	a	9	10	9	10	–	
			b	9	10	9	10	–	
			c	10	10	10	10	–	
148	Polyester (8.5 mil)	4	a	9	10	9	10	10	
			b	9	10	9	10	2/L	
			c	9	10	9	9	6/L	
		5	a	9	10	9	10	10	
			b	9	10	9	10	5/L	
			c	9	10	9	9	8/L	
		6	a	9	10	9	10	10	6 to 7 years – Pinpoint rusting in zones a and b.
			b	8	10	8	9	2/L	
			c	9	10	9	9	7/L	
		7	a	9	10	9	9	10	
			b	8	10	8	9	4/M	
			c	9	10	9	9	6/L	
		8	a	8	10	8	9	10	
			b	8	10	8	9	2/L	
			c	8	10	8	9	8/L	

continued

Series 7 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
148 cont'd		9	a	7	10	7	8	10	
			b	8	10	8	9	2/L	
			c	8	10	8	9	6/L	
148a	Fiberglass-filled polyester (10.5 mil)	4	a	9	10	9	9	10	4 years – Small damaged area along edge in zone b.
			b	9	10	9+	10	2/M	
			c	9	10	10	9	6/L	
		5	a	9	2/F	9	9	10	
			b	9	10	9	10	2/L	
			c	9	10	9	9	8/L	
		6	a	9	2/F	9	9	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	8/L	
		7	a	8	2/F	9	8	10	6 to 8 years – Cracking on edge zones b and c.
			b	9	10	9	10	5/L	
			c	9	10	9	10	7/L	
		8	a	8	2/F	8	7	10	6 to 8 years – Barnacles have removed topcoat along edges. Near failure in zone a.
			b	8	10	8-	9	2/L	
			c	9	10	9	9	6/L	
		9	a	6	10	8	6	10	
			b	8	10	8	7	/L	
			c	8	10	8	8	/L	
Series 8									
149	Coal tar-epxoy over zinc-filled polyether (30.5 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	9+	10	9+	10	8/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	9+	10	9+	10	6/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
149 cont'd		5	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	9+	10	9+	10	6/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	9+	10	9+	10	4/H	
		7	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	9	10	9	10	6/M	
		8	a	10	10	10	10	10	
			b	10	10	10	10	/L	
			c	9	10	9	10	/M	
		9	a	10	10	10	10	10	
			b	9	10	9	10	/VL	
			c	9	10	9	10	/VL	
150	Vinyl mastic over zinc-filled polyether (15.0 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	2/M	
			c	10	10	10	10	7/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	8/L	
		5	a	10	10	10	10	10	
			b	10	10	10	10	2/M	
			c	10	10	10	10	5/M	
		6	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/M	
		7	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	4/H	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
150 cont'd		8	a	10	10	10	10	10	
			b	10-	10	10	10	/L	
			c	10-	10	10	10	/M	
		9	a	10	10	10	10	10	9 years – Barnacles have removed topcoat to primer in zone b. New fouling – very light.
			b	9+	10	10	9+	/L	
			c	9+	10	10	9+	/L	
151	Aluminum-pigmented vinyl over zinc-filled polyether (12.5 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	8/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	2/M	
			c	10	10	10	10	5/M	
		5	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/M	
		6	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	4/H	
		7	a	10	10	10	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	
		8	a	10	10	10	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	
		9	a	10	10	10	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	
152	Saran (formula 113/54) over zinc-filled polyether (9.5 mil)	3	a	10	10	10	10	10	3 to 5 years – Very light pinpoint rusting in zones b and c.
			b	9+	10	9+	10	4/L	
			c	9+	10	9+	10	7/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
152 cont'd		4	a	10	10	10	10	10	
			b	9+	10	9+	10	2/L	
			c	9+	10	9+	10	8/L	
		5	a	9+	10	9+	10	10	
			b	9+	10	9+	10	4/M	
			c	9+	10	9+	10	6/L	
		6	a	9+	10	9+	10	10	
			b	9+	10	9+	10	2/L	
			c	9+	10	9+	10	6/L	
		7	a	9+	10	9+	10	10	
			b	9	10	9+	10	3/L	
			c	9	10	9+	10	8/L	
		8	a	9+	10	9	10	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
		9	a	9	10	9	10	10	9 years – Barnacles removed topcoat in zone b.
			b	9	10	9	10	/M	
			c	9	10	9	10	/L	
153	Epoxy over zinc-filled epoxy (10.0 mil)	3	a	9+	10	9	10	10	
			b	9+	10	9	10	2/L	
			c	9+	10	9	10	8/L	
		4	a	9	10	9	10	10	
			b	9	10	9	10	6/L	
			c	9	10	9	10	9/L	
		5	a	9	10	9	10	10	5 years – Mechanical damage, zone c top.
			b	9	10	9	10	4/L	
			c	9	10	9	10	8/L	
		6	a	9	10	9	10	10	6 to 7 years – Slight pitting, zone c.
			b	9	10	9	10	2/M	
			c	9	10	9	10	6/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
153 cont'd		7	a	9	10	9	10	10	7 to 8 years – Few galvanic corrosion spots zone c.
			b	9	10	9	10	3/L	
			c	9	10	9	10	5/L	
		8	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
		9	a	9	10	9-	10	10	
			b	9	10	9	10	/M	
			c	9	10	9	10	/VL	
154	Vinyl mastic over zinc-filled epoxy (15.0 mil)	3	a	9+	10	9	10	10	3 years – Barnacles removed topcoat in two or three small spots zone b.
			b	9+	10	9	10	4/M	
			c	9+	10	9	10	8/L	
		4	a	9	10	9	10	10	4 to 9 years – Edge rusting.
			b	9	10	9	10	2/L	
			c	9	10	9	10	8/L	
		5	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	6/L	
		6	a	9	10	9	10	10	
			b	9	10	9	10	2/L	
			c	9	10	9	10	8/L	
		7	a	9	10	9	10	10	
			b	9	10	9	10	4/L	
			c	9	10	9	10	9/L	
		8	a	9	10	9	10	10	7 to 9 years – Slight erosion along edges. Topcoat removed from primer in a few spots by barnacles.
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	/H	
			c	8	10	8	10	/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
155	Aluminum-pigmented vinyl over zinc-filled epoxy (14.0 mil)	3	a	10	10	10	10	10	3 years – Primer showing on edges.
			b	10	10	10	10	6/L	
			c	10	10	10	10	3/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	8/L	
		5	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	6/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	
		7	a	9+	10	9+	10	10	7 years – Small damaged spot, lower end. Light pitting.
			b	10	10	10	10	4/L	
			c	10	10	10	10	9/L	
		8	a	9	10	9	10	10	8 to 9 years – Galvanic corrosion, lower-end.
			b	9	10	9	10	/L	
			c	9	10	9	10	/L	
		9	a	9	10	9	10	10	
			b	9	10	9	10	/M	
			c	9	10	9	10	/VL	
156	Saran (formula 113/54) over zinc-filled epoxy (9.0 mil)	3	a	10-	10	10-	10	10	3 to 6 years – Very light pinpoint rusting in zone a.
			b	10	10	10	10	4/L	
			c	10	10	10	10	8/M	
		4	a	10-	10	10-	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	7/L	
		5	a	10-	10	9+	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	8/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
156 cont'd		6	a	10-	10	9+	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	6/L	
		7	a	9+	10	9+	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	
		8	a	9	10	9	10	10	
			b	9+	10	9+	10	/L	
			c	10	10	10	10	/L	
		9	a	9	10	9	10	10	9 years – Edge rusting.
			b	9	10	9	10	–	
			c	9+	10	9+	10	–	
157	Coal tar-epoxy over zinc-filled epoxy (19.5 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	9/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/L	
		5	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	4/H	
			c	10	10	10	10	6/H	
		7	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	7/M	
		8	a	10	10	10	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
157 cont'd		9	a	9+	10	9+	10	10	
			b	10	10	10	10	–	
			c	10	10	10	10	–	
158	Vinyl mastic over zinc-filled epoxy (16.0 mil)	3	a	10	10	10	10	10	3 to 9 years – Barnacles have removed topcoat from primer in zone b.
			b	10	10	10	10	4/M	
			c	10	10	10	10	8/L	
		4	a	10	10	10	10	10	
			b	10	2/F	10	10	2/L	
			c	10	10	10	10	6/L	
		5	a	10	10	10	10	10	
			b	10	2/F	10	10	5/L	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	2/F	10	10	2/H	
			c	10	2/F	10	10	7/L	
		7	a	10	10	10	10	10	
			b	10-	2/F	10	10	4/L	
			c	10-	2/F	10	10	6/M	
		8	a	10	10	10	10	10	
			b	10-	10	10	10	/M	
			c	10-	10	10	10	/M	
		9	a	9+	10	9+	10	10	
			b	9	10	9	10	/L	
			c	9+	10	9	10	/L	
159	Aluminum-pigmented vinyl over zinc-filled epoxy (13.0 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
159 cont'd		5	a	10	10	10	10	10	
			b	10	10	10	10	3/M	
			c	10	10	10	10	6/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	5/H	
		7	a	10	10	10	10	10	6 to 9 years – Slight fouling damage in zone b where barnacles have removed vinyl coating from zinc primer. No rusting.
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/M	
		8	a	10	10	10	10	10	
			b	10-	10	10	10	/L	
			c	10-	10	10	10	/M	
		9	a	10-	10	9+	10	10	9 years – Light to moderate flaking of vinyl system from zinc pigment in zones b and c. Edge rusting all 3 zones.
			b	9	2/F	9	9	/M	
			c	9	10	9	10	/L	
160	Saran (formula 113/ 54) over zinc-filled epoxy (10.0 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	8/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	9/L	
		5	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	6/L	
		6	a	10-	10	10-	10	10	6 to 9 years – Very light pinpoint rusting in zone a.
			b	10	10	10	10	2/M	
			c	10	10	10	10	7/M	
		7	a	10-	10	10-	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting		Fouling[b] Attachment	Remarks
						1	2		
160 cont'd		8	a	9+	10	10-	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/L	
		9	a	9+	10	10-	10	10	
			b	10	10	10	10	/M	
			c	10	10	10	10	/L	
161	Alkyd enamel over zinc-filled epoxy (9.5 mil)	3	a	9+	10	9	10	10	3 to 6 years – Moderate to heavy loss of adhesion of alkyd system to zinc primer in zones b and c.
			b	8	10	8	10	4/M	
			c	9	2/F	9	10	8/L	
		4	a	9	10	9	10	10	
			b	8	10	8	10	2/L	
			c	8	2/F	8	10	6/L	
		5	a	9	10	9	10	10	5 to 9 years – Where alkyd system removed, pinpoint rusting noted on zinc primer.
			b	8	10	8	10	2/L	
			c	8	2/F	8	10	6/M	
		6	a	9	10	9	10	10	6 to 9 years – Light pitting in zone c. Most of alkyd top-coat removed in zones b and c. Removal due to barnacle damage and general loss of adhesion.
			b	8	2/F	8	8	2/M	
			c	8	2/F	8	10	6/L	
		7	a	9	10	9	10	10	
			b	7	2/F	8	8	3/L	
			c	8	2/F	8	10	7/L	
		8	a	9	10	9	10	10	8 to 9 years – Galvanic corrosion in zones b and c.
			b	7	10	7	8	/L	
			c	6	10	8	5	/L	
		9	a	9	10	8	10	10	9 years – System removed from test.
			b	7	2/F	7	8	/L	
			c	5	10	8	5	/L	
162	Vinyl mastic over zinc-filled epoxy (16.0 mil)	3	a	10	10	10	10	10	
			b	9	10	9	10	2/M	
			c	10	2/F	10	10	6/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
162 cont'd		4	a	10	10	10	10	10	
			b	9	10	9	10	4/L	
			c	10	2/F	10	10	6/L	
		5	a	10	10	10	10	10	
			b	9	10	9	10	5/L	
			c	10	2/F	10	10	8/L	
		6	a	10	10	10	10	10	
			b	9	10	9	10	2/H	
			c	10	2/F	10	10	5/H	
		7	a	10	10	10	10	10	
			b	9	10	9	10	5/L	
			c	10	10	10	10	8/L	
		8	a	10	10	10	10	10	8 years – Barnacles removed topcoat to primer in small areas of zones b and c.
			b	9	10	9	10	/L	
			c	10	10	10	10	/L	
		9	a	10–	10	10-	10	10	
			b	9	10	9	10	/H	
			c	9	10	9	10	/L	
163	Aluminum-pigmented vinyl over zinc-filled epoxy (12.0 mil)	3	a	10	10	10	10	10	
			b	9+	10	10-	10	2/L	
			c	10	10	10	10	7/M	
		4	a	10	10	10-	10	10	4 to 9 years – Light to moderate fouling damage in zones b and c has removed topcoat from primer or organic system from zinc primer in zones b and c, permitting rusting.
			b	9+	10	10-	10	4/L	
			c	10	10	10	10	6/L	
		5	a	10	10	10-	10	10	
			b	9+	2/F	10-	10	3/M	
			c	9+	2/F	10-	10	7/L	
		6	a	9	10	9	10	10	
			b	9+	2/F	10-	10	2/H	
			c	9+	2/F	10-	10	4/H	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
163 cont'd		7	a	9	10	9	10	10	
			b	9+	10	10-	10	2/L	
			c	9+	10	10-	10	8/L	
		8	a	9	10	9	10	10	
			b	9	10	9	10	/L	
			c	7	10	7	10	/L	
		9	a	9	10	9	10	10	
			b	8	10	8	10	/L	
			c	7	10	7	10	/L	
164	Saran (formula 113/ 54) over zinc-filled epoxy (10.5 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	4/M	
			c	10	10	10	10	5/M	
		4	a	9+	10	9+	10	10	
			b	10	2/F	10	10	2/L	
			c	10	10	10	10	8/L	
		5	a	9+	10	9+	10	10	4 to 5 years – Slight pinpoint rusting zone a.
			b	10	2/F	10	10	4/L	
			c	10	10	10	10	8/L	
		6	a	9+	10	9+	10	10	
			b	10	2/F	10	10	2/L	
			c	10	10	10	10	6/L	
		7	a	9+	10	9+	10	10	
			b	10	2/F	10	10	5/L	
			c	10	10	10	10	6/L	
		8	a	9	10	9	10	10	8 to 9 years – Light fouling damage, zones b and c, mostly along edges.
			b	9	10	9	10	/L	
			c	10	10	10	10	/L	
		9	a	9	10	9	10	10	
			b	8	10	9	9	/L	
			c	9	10	9	10	/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting		Fouling[b] Attachment	Remarks
						1	2		
165	Epoxy over zinc-filled epoxy (9.5 mil)	3	a	9+	10	9+	10	10	
			b	9+	10	9+	10	4/M	
			c	9+	10	9+	10	6/L	
		4	a	9	10	9	10	10	
			b	9	10	9	10	5/L	
			c	9	10	9	10	7/L	
		5	a	9	2/F	9	9	10	5 to 9 years – Blistering in zone a primarily along edges.
			b	9	10	9	10	4/L	
			c	9	10	9	10	8/L	
		6	a	9	2/F	9	10	10	
			b	9	10	9	10	4/H	
			c	9	10	9	10	6/H	
		7	a	9	2/F	9	9	10	
			b	9	10	9	10	2/L	
			c	9	10	9	10	8/L	
		8	a	8	2/F	9	8	10	
			b	9	10	9	10	/M	
			c	9	10	9	10	/M	
		9	a	8	2/MD	8	8	10	9 years – Light pitting along edge of zone c.
			b	9	2/F	9	10	/L	
			c	9	2/F	9	9	/L	
166	Vinyl mastic over zinc-filled epoxy (16.5 mil)	3	a	10	10	10	10	10	
			b	9+	10	9	10	–	
			c	10	10	10	10	–	
		4	a	10	10	10	10	10	
			b	9+	10	9	10	–	
			c	10	10	10	10	–	
		5	a	10	10	10	10	10	
			b	9	10	9	10	–	
			c	10	10	10	10	–	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
166 cont'd		6	a	10	10	10	10	10	
			b	9	10	9	10		
			c	10	10	10	10		
		7	a	10	10	10	10	10	7 to 9 years – Fouling damage in zones b and c has removed topcoat from primer. Edge rusting in zone b.
			b	9	10	9	10		
			c	10	10	10	10		
		8	a	10	10	10	10	10	
			b	9+	10	9	10		
			c	10	10	10	10		
		9	a	10	10	10	10	10	
			b	9	10	9	10		
			c	10	10	10	10		
167	Aluminum-pigmented vinyl over zinc-filled epoxy (14.0 mil)	3	a	10	10	10	10	10	
			b	10	10	10	10	2/H	
			c	10	10	10	10	5/M	
		4	a	10	10	10	10	10	Slight fouling damage zone b and c.
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	
		5	a	10	10	10	10	10	5 to 9 years – Very light fouling damage in zones b and c.
			b	10	10	10	10	3/M	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	7/L	
		7	a	9+	10	9	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	6/L	
		8	a	9	2/F	9	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/L	

continued

AD-A053 504 CIVIL ENGINEERING LAB (NAVY) PORT HUENEME CALIF F/G 11/3
PROTECTIVE COATINGS FOR STEEL PILING: ADDITIONAL DATA ON HARBOR--ETC(U)
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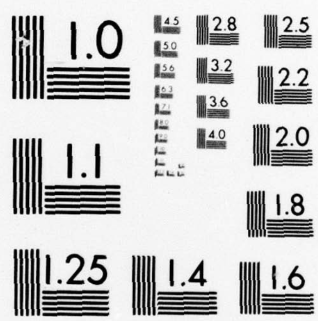

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/Frequency)	Rusting 1	Rusting 2	Fouling[b] Attachment	Remarks
167 cont'd		9	a	9	2/F	10	10	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/L	
168	Saran (formula 113/54) over zinc-filled epoxy	3	a	10	10	10	10	10	
			b	10	2/F	10	10	2/M	
			c	10	10	10	10	8/L	
		4	a	10	10	10	10	10	
			b	10	10	10	10	4/L	
			c	10	10	10	10	7/L	
		5	a	10	10	10	10	10	
			b	10	2/F	10	10	4/M	
			c	10	10	10	10	8/L	
		6	a	10	10	10	10	10	
			b	10	2/F	10	10	2/M	
			c	10	10	10	10	5/M	
		7	a	10	10	10	10	10	
			b	10	2/F	10	10	4/L	
			c	10	10	10	10	8/L	
		8	a	10	10	10	10	10	
			b	10	2/F	10	10	/L	
			c	10	10	10	10	/L	
		9	a	9+	10	9+	10	10	9 years – Rusting along edges in all 3 zones.
			b	9	2/F	9	10	/	
			c	9+	10	9	10	/	
169	Saran (formula 113/54) (6.0 mil)	3	a	9+	10	9+	10	10	3 to 9 years – Few pinpoint rust areas in zone a.
			b	10	10	10	10	4/M	
			c	10	10	10	10	9/L	
		4	a	9+	10	9+	10	10	
			b	10	10	10	10	5/L	
			c	10	10	10	10	8/L	

continued

Series 8 (continued)

System No.	System Description and Thickness	Years Exposed	Zone	Protection	Blistering[a] (Size/ Frequency)	Rusting		Fouling[b] Attachment	Remarks
						1	2		
169 cont'd		5	a	9+	10	9+	10	10	
			b	10	10	10	10	2/L	
			c	10	10	10	10	8/L	
		6	a	9+	10	9+	10	10	
			b	10	10	10	9+	2/M	
			c	10	10	10	10	6/L	
		7	a	9+	10	9+	10	10	
			b	10	10	10	9+	2/L	
			c	10	10	10	10	8/L	
		8	a	9	10	9	9	10	
			b	10	10	10	10	/L	
			c	10	10	10	10	/L	
		9	a	9	10	9	10	10	
			b	9+	10	9+	10	/L	
			c	9	10	9	10	/L	

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